SOME INTERESTS ENTOMOLOGISTS AND NEMATOLOGISTS HAVE IN COMMON [1]

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Insects and nematodes have been living together in close association for a long time. Many intimate interrelationships have evolved. Among these relationships are some of the most interesting and amazing examples of biological adaptation that occur anywhere in the field of zoology. This is not surprising. These relationships have been evolving over a vast period of time. There were nematode parasites of insects long before there were nematode parasites of vertebrates, or any vertebrates to parasitize for that matter. Speaking phylogenetically, the parasites of insects include what are, without much doubt, the oldest nematode parasites known. Compared with these the parasites of vertebrates are rank newcomers to a parasitic mode of life. Many of the parasites of plants have become adapted to parasitism rather recently, but not all. Some of these are obviously old.

I shall endeavor to discuss with you some of these interrelationships between insects and nematodes. I cannot begin to cover them all. The best I can do is make a few general remarks and select a few examples. Some of the examples selected represent extremes, that is the end products of evolutionary adaptations. Many of the intermediate steps are known.

Nematodes of the families Rhabditidae and Diplogasteridae are preeminently scavengers living in dung or in decaying organic matter of one kind or another. *Rhabditis coarctata*, for example (9), lives in dung. As long as the dung is fresh and moist, this nematode reproduces rapidly and builds up enormous populations. When the dung begins to get old and dry, larvae by the thousands climb to the tops of upward pointing projections. Here they become attached by their tails and wave their bodies about like a miniature field of grain. Hundreds of these larvae may be wiped off and stick to the first dung beetle that happens to come walking by. After all, what better way of getting to some fresh dung than to thumb a ride on a dung beetle.

The hookworms, parasites of man, dogs, cats, and some other animals, are skin penetrators. They enter their hosts by penetrating the skin, migrating into the lymphatics and thence to the blood stream. Eggs hatch in fecal-contaminated soil. Newly hatched larvae climb to the tops of upward pointing projections. Here they become attached by their tails and wave their bodies about in anticipation of being wiped off, not in this case by a passing insect, but by the proverbial barefoot boy or by his dog. The rhabditids are the closest living relatives of the ancestors of the hookworms. Early-stage hookworm larvae look so much like the early stages of many rhabditids that parasitologists have difficulty in telling them apart. It is my contention that when parasitologists are watching the behavior of hook worm larvae that results in skin penetration they are looking at a

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fragment of history, a behavior pattern evolved long ago that enabled the ancestors of the hookworms to be disseminated by insects.

Back in the days when vinegar was made, not by the chemist, but by the fermentation of apple juice "down by the wineger works," the vinegar eel was a first-class nuisance. Not that it caused any public health hazard, it merely added a little protein to the vinegar. But people objected to having eelworms in their vinegar and, unfortunately, the vinegar eel is a moderately large nematode not too difficult to see. Precautions that seemed adequate to keep the vinegar eel out all too frequently failed. When the puzzle was solved the solution was very simple. The nematode was being disseminated by fruit flies of the genus *Drosophila*. While the precautions may have been adequate to keep out the vinegar eel, they were not adequate to keep out the fruit flies.

When Cobb (3) was investigating the red ring disease of coconutpalms, he found that the causal organism, the coconutpalm nematode, was being disseminated by the palm weevil, *Rhyncophorus palmarum*. Snyder and Zetek (8) reported one instance where this same nematode was being carried from diseased to healthy palms by termites. Fenwick (6), who is at present engaged in investigating the red ring disease in Trinidad, is inclined to doubt the importance of the palm weevil as a vector, but he does not deny that dissemination in this manner may occur.

I have selected the two last-mentioned examples of dissemination of nematodes by insects largely because they have an economic slant. Let us now turn to the scavengers and to associations between these and insects of an entirely different kind.

If you should undertake to dissect miscellaneous insects and examine them for nematodes, you would be likely to find, in the intestine, small immature forms. These would be found in many different kinds of insects but never in large numbers, usually only one, at the most only a few. They would all be in about the same stage of development, so immature that it would be difficult to identify them, even to family. These larval nematodes remain passively in the intestine without maturing and apparently without causing the insect any harm. But when the insect dies or is killed, these nematodes mature and reproduce rapidly in the decaying carcass.

Some of the nematodes of this general group are not so innocuous. Becoming impatient of waiting until the insect dies of other causes, they have developed a method whereby they can hasten matters along. This is accomplished, so we are told, by a bacterium, carried in by the nematode that kills the insect. *Neoaplectana glaseri* belongs in this category. You are all familiar, no doubt, with the work of Glaser (7) and his colleagues in their endeavors to use this nematode as an agent for controlling the Japanese beetle, *Popillia japonica*. They studied its life history and habits in detail and developed methods for rearing it on a large scale with artificial media. Their efforts to control the Japanese beetle on a field scale by inoculating the soil with this nematode met with some measure of success. We might have heard more about this method had not the milky disease seemed to be somewhat more effective and easier to handle. Furthermore, it may have been easier to sell the idea of controlling an insect with a bacterial disease than of controlling it with a nematode.

Dutky and Hough (5) experimented with a related species of *Neoaplectana* obtained originally from infected codling moth larvae, *Carpocapsa pomonella,* collected in Virginia. In the laboratory they found the nematode capable of producing fatal infections in many insects, including the European corn borer, *Pyraustia nubilalis;* the armyworm, *Pseudaletia unipuncta;* the tobacco moth, *Ephestia elutella;* a sawfly, *Neodipyrion* sp.; and several others. The nematodes for these experimental inoculations were obtained by rearing in larvae of the wax moth, *Galleria mellonella.* A press release relating to this work mentioned tests with disseminating the nematodes through spray nozzles in the routine application of sprays.

More recently, Welch (10) reported results of trials with this same nematode for controlling the Colorado potato beetle, *Leptinotarsa decemlineata.* Nematodes suspended in water were applied with a hand sprayer. In spite of rains following application that may have washed off many of the nematodes, enough beetles and larvae became infected to reduce the insect population by about 35 percent.

Although species of *Neoaplectana* and other nematodes that have similar habits are usually referred to as parasites, they are primarily scavengers. Now let us direct our attention to some nematodes that are, in fact, true parasites of insects. It should be noted, at this point, that many of the nematode parasites of man and of domesticated animals use an intermediate host as a means of gaining entrance to their final or definitive host. All species of the superfamilies Spiruroidea and Fliarioidea, as well as some members of other groups, have intermediate hosts in their life cycles. The transmission of filariasis by mosquitoes is a matter of common knowledge. Most of these intermediate hosts are arthropods, many of them insects. These do not concern us in the present discussion, but I mention them in passing to help round out the picture.

Most of the parasites of insects can be divided into two groups, those found in the intestine and those found in the body cavity. The parasites of the intestine have very simple life cycles and are not outstandingly different from many other nematodes. The parasites of the body cavity have complicated life cycles and are outstandingly different from all other nematodes. The body-cavity parasites that I will discuss are of two families, the Mermithidae and the Allantonematidae.

The mermithids are a large group; there are many species. They are preeminently, though not exclusively, parasites of arthropods, mostly insects. They have been reported from more different kinds of insects than any of the other groups of nematode parasites. Through the work of Wheeler (11), entomologists are perhaps most likely to know about the parasites of ants. A mermithid does queer things to the development of casts in ants, some of the parasitized individuals being intermediate between queens and soldiers or between soldiers and workers, and some not resembling any normal cast. The so-called cabbage hairworm has been seen so frequently on heads of cabbage, and so many inquiries were received about it, that the U. S. Department of Agriculture once published a circular explaining what it is and reassuring people that it is not dangerous to man. Obviously, it is a parasite of some insect that feeds on cabbage, but which one, so far as I know, has never been determined. The two

species whose life cycles are the most completely known are parasites of grasshoppers. These are *Agamermis decaudata* and *Mermis subnigrescens*.

Agamermis decaudata (1) is a common parasite of grasshoppers in Virginia and, no doubt, in other parts of the upper South. Briefly, its life cycle is this: The fully-grown but sexually-immature parasites force their way out their grasshopper hosts sometime during late summer or early autumn, fall to the ground, and enter the soil. Here they reach sexual maturity, copulate, and lay eggs. Females that emerge from their hosts one year will reach maturity and be laying eggs the following spring at the time grasshopper eggs are hatching. Newly hatched mermithid larvae migrate to the surface of the soil and climb grass and other low vegetation when it is wet with dew or rain. Here they seek and enter newly hatched grasshopper nymphs by penetrating the body wall.

These preparasitic larvae of *Agamermis* are remarkable organisms. They are about 5 mm. long, very slender, and exceedingly active. The body is divided into two sections by a node. The anterior section contains all the usual organs but is only about one-fifth the total length. The remaining four-fifths is a food storage and propelling organ. During the process of penetrating the host, the body breaks at the node and this propelling organ is discarded and remains on the outside.

Mermis subnigrescens (2) is a common parasite of grasshoppers throughout New England and at least as far west as Wisconsin. Its life cycle is essentially the same as that of *Agamermis decaudata* with one important difference. Females do not lay their eggs in the soil. Instead they come to the surface and lay their eggs on low vegetation during spring rains. The eggs are provided with entangling appendages for attachment to the foliage. In the case of *Agamermis*, which grasshoppers acquire while they are young nymphs, the usual condition is one parasite per host. In the case of *Mermis*, which grasshoppers can acquire at any time while feeding, one host frequently harbors a considerable number and they may be of different ages.

The effect of mermithids on grasshoppers is to retard the development of the reproductive organs and render the insects sterile. *Agamermis*, which is always acquired while the insect is very young, will invariably render a female grasshopper sterile. *Mermis* will usually render a female sterile but whether or not will depend on the number of parasites and, more especially, the age of the insect when they were acquired. The effects of these parasites on the male grasshopper is the same as their effects on the female but tends to be somewhat less pronounced. Mermithids always kill their hosts when they emerge to enter the soil.

Some of you will be raising the question as to whether or not mermithids do, in fact, have any appreciable effect in holding grasshopper populations in check. No one can answer this question and support his answer with precise data. The best one can do is express an opinion based on field observations and such other information as is available.

During August 1930, collections were made in 83 fields, most of them in the Merrimack and Connecticut River valleys of New England. In each field, 100 grasshoppers were collected and examined. The percentage harboring mermithids was as follows:

1 field	80%
2 fields	50 to 59%
3 fields	40 to 49%
7 fields	30 to 39%
11 fields	20 to 29%
19 fields	10 to 19%
30 fields	1 to 9%
10 fields	None
Average	12%

I think all who were engaged in these investigations came to the conclusion that mermithids do exert a very great influence in suppressing grasshopper populations. It may be more than coincidence that serious grasshopper epidemics rarely occur in regions where mermithids are known to be present. The weak point in the life cycle of both these species of mermithids is that it can be completed (i.e., grasshoppers become infected) only where climatic conditions provide periods when there is dew or rain. Frequently, it is possible to control a pest by taking advantage of a weak point in its life cycle. By the same token, a weak point in the life cycle may limit the usefulness of a parasite as an agent in biological control.

Now let us direct our attention to one example of that other group of body-cavity parasites, the Allantomatidae. *Fergusonina* is a genus of flies that cause galls on *Eucalyptus* trees. There are many species of this genus in Australia, and the parts of the trees where the galls are formed differs with the species. Each species of fly is believed to live in association with a nematode, though probably not the same species of nematode. The fly used in the study of this association (4) was *Fergusonina nicholsonia*, and it causes galls in the flower buds. The associated nematode was named *Fergusobia curriei*.

The fly deposits its eggs on the flower buds and with each egg it deposits from 1 to 50 nematode larvae. The same fly, or different flies, may lay several eggs in one bud. The larval nematodes begin to feed on the anther primordia that forms a ring of cells at the base of the bud cavity. The cells respond in exactly the same way that many plant tissues respond to the feeding of plant-parasitic nematodes. They begin to divide and form a mass of large, thin-walled, parenchymatous cells filled with a mucilaginous sap. The nematodes, feeding on this plant tissue, mature into females and pass through several parthenogenetic generations.

While all this is going on, the eggs of the fly hatch, after about six days, and the fly larvae move into the mass of parenchymatous tissue and form cavities. Here they proceed in their development, feeding on the mucilaginous sap that oozes from the ruptured plants cells. As the fly larvae complete their development, but before they pupate, the nematodes suddenly produce a generation composed of both sexes. These quickly reach sexual maturity, copulate, and the males die. Two, and only two, of the impregnated female nematodes enter the body cavity of each female fly larva by penetrating the body wall. Fly larvae destined to become males are never invaded, females invariably. In the body cavity, the nematodes grow rapidly and undergo the same kind of parasitic degeneration that is characteristic of most allantomatids. They become little more than sacks filled with the reproductive organs.

Eggs are deposited and hatch in the body cavity of the insect. The resulting nematode larvae migrate into the female goniduct and assemble at the posterior end. From here they will be extruded with the eggs when the fly starts ovipositing on the buds of *Eucalyptus* trees.

Those who have studied this association are inclined to regard the stages of the nematode that occur in the galls as true plant parasites, but the relationship with the gall flies as symbiosis. While they do not say in so many words that the fly could not exist without the nematode, their comments seem to carry this implication.

I would like to point out, in closing, that these interrelationships between insects and nematodes have been studied by only a few investigators. For the most part, they are associations that these investigators stumbled onto by accident. I feel sure the ones we know about represent but a small fraction of the ones that exist.

Literature Cited

Christie, J. R. 1936. The life history of *Agamermis decaudata*, a nematode parasite of grasshoppers and other insects. Jour. Agr. Res. 52 (3): 161-198.

Christie, J. R. 1937. *Mermis subnigrescens*, a nematode parasite of grasshoppers. Jour. Agr. Res. 55 (5): 353-364.

Cobb, N. A. 1919. A newly discovered nematode, *Aphelenchus cocophilus* n. sp. connected with a serious disease of the coco-nut palm. W. Indian Bull. 17 (4): 203-210.

Currie, G. A. 1937. Galls on *Eucalyptus* trees. A new type of association between flies and nematodes. Proc. Linn. Soc. N. S. Wales 62 (3-4): 147-174.

Dutkey, S. R., and *W. S. Hough.* 1955. Note on a parasitic nematode from codling moth larvae, *Carpocapsa pomonella.* Proc. Ent. Soc. Wash. 57 (5): 244.

Fenwick, D. W. 1957. Red ring disease of coconuts in Trinidad and Tobago. Report. London. Colonial Office, 55 pp.

Glaser, R. W., E. E. McCoy, and *H. B. Girth.* 1940. The biology and economic importance of a nematode parasitic in insects. Jour. Parasitol. 26 (6): 479-495.

Snyder, E. T., and *J. Zetek.* 1924. Damage by termites in the Canal Zone and Panama and how to prevent it. U. S. Dept. Agr. Bull. 1232.

Triffitt, Marjorie J., and *J. N. Oldham.* 1927. Observations on the morphology and bionomics of *Rhabditis coarctata* Leuck. occurring on dung beetles. Jour. Helminth. 5 (1): 33-46.

Welch, H. E. 1957. Test of a nematode and its associated bacterium for control of the Colorado potato beetle, *Leptinotarsa decemlineata* (Say). Ann. Rept. Ent. Soc. Ontario 88: 53-54.

Wheeler, W. M. 1928. *Mermis* parasitism and intercasts among ants. Jour. Expt. Zool. 50 (2): 165-237.

SEASONAL POPULATIONS OF CITRUS INSECTS AND MITES IN COMMERCIAL GROVES [1]

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Populations of the major insects and mites that affect citrus are known to vary from month to month as each species passes through its life cycle and responds to environmental changes. Also well recognized is the variation in abundance of a major insect or mite pest from year to year.

In the case of minor citrus pests, fluctuations in population are less well known because these species usually have been studied only in limited areas and mainly during outbreak years.

Very little information on the range of population sizes in Florida groves has appeared in the literature. The purpose of this paper is to present population data obtained from observations made each month from 1951 through 1958. These data, taken from 130 representative groves, reflect the influence of natural ecological factors plus the effects of pest control practices used in a majority of groves.

The population records obtained have been used to express the average abundance of 19 citrus pests throughout the Florida citrus belt during each month of the year. By utilizing records of maximum and minimum populations that occurred in the 8-year period, it has been possible to delimit a probable range of fluctuation for a number of species. Although it is not the intention in this paper to dwell upon factors that cause population changes, some comments are included regarding unusual populations that followed the cold winter of 1957-58.

METHODS

Populations were determined each month over a period of eight and and a half years from January 1951, through July 1959, for the following citrus pests:

1. Citrus rust mite, *Phyllocoptruta oleivora* (Ashm.)
2. Purple scale, *Lepidosaphes beckii* (Newm.)
3. Citrus red mite, *Panonychus citri* (McG.), commonly called purple mite in Florida.
4. Black scale, *Saissetia oleae* (Bern.)
5. Red scale, *Chrysomphalus aonidum* (L.)
6. Texas citrus mite, *Eutetranychus banksi* (McG.)
7. Whiteflies in populations consisting of one or more of the following species: cloudy-winged whitefly, *Dialeurodes citrifolii* (Morg.); citrus whitefly, *D. citri* (Ashm.); wooly whitefly, *Aleurothrixus floccossus* (Mask.)
8. Citrus mealybug, *Pseudococcus citri* (Risso)
9. Soft scale, *Coccus hesperidum* L., also known as soft brown scale.
10. Aphids in populations comprising one or more of the follow-

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ing species: citrus or spirea aphid, *Aphis spiraecola* Patch; cotton or melon aphid, *Aphis gossypii* Glov.; black citrus aphid, *Toxoptera aurantii* (Fonsc.)
12 Six-spotted mite, *Eotetranychus sexmaculatus* Riley
13 Chaff scale, *Parlatoria pergandii* Comst.
14 Florida wax scale, *Ceroplastes floridensis* Comst.
15 Glover's scale or long scale, *Lepidosaphes gloverii* (Pack.)
16 Yellow scale, *Aonidiella citrina* (Coq.)
17 Cottony cushion scale, *Icerya purchasi* Mask.
18 Fern scale, *Pinnaspis aspidistrae* (Sign.)
19 Dictyospermum scale, *Chrysomphalus dictyospermi* (Morg.)
20 Citrus snow scale, *Unaspis citri* (Comst.)

This study was part of a continuous survey of ecological factors affecting citrus production, conducted under Florida Agricultural Experiment Station Project 606. The procedures used in this project that pertain to these population studies were as follows:

One hundred and thirty groves were selected throughout the Florida citrus belt to represent as proportionally as possible the acreage, varieties, rootstocks, spray programs, and weather conditions that prevail in the commercial citrus producing area. Approximately 13 per cent of these groves received little or no pesticidal treatment, whereas the majority were on a fairly complete pest control program.

Five trees representative of each grove were tagged as count trees. Except in a few cases where it was necessary to substitute another grove or to change from trees that became atypical within a grove, the same trees were always observed.

Populations of purple and red scales were determined by examining under a microscope both surfaces of the basal quarter of 50 leaves from each tree and recording the percentage of leaves infested with living scales.

Black scale was determined by observing 12 inches of twig nearest the stem on 10 fruiting terminal twigs per tree using 2X magnification. The percentage of infested terminals was recorded.

Citrus red (purple) mite, Texas citrus mite, and six-spotted mite populations were determined by examining 20 leaves per tree with 2X magnification and recording the number of leaves infested with each species.

Rust mite populations were obtained from an examination of 20 leaves with a 10X hand lens. If a mite was seen in two lens fields, one on each surface of the leaf, the leaf was counted as infested.

Populations of minor pests were estimated from a 5 minute gross inspection of each tree and from the number of individuals seen during the detailed examination for major pests. Extent of infestation was recorded as class 0, 1, 2, or 3, indicating respectively no infestation, very light infestation, light to moderate infestation, and moderate to heavy infestation. In general, class 2 indicated an infestation of 5 to 19 percent of the twigs, fruit, or leaves infested and classes 1 and 3 indicated lower or higher populations. Using the classes thus assigned, a population index was calculated each month for the group of 130 groves. This was done by a weighting procedure in which the number of groves with class 1 infestation was multiplied by 1, the number with class 2 multiplied by 2, and

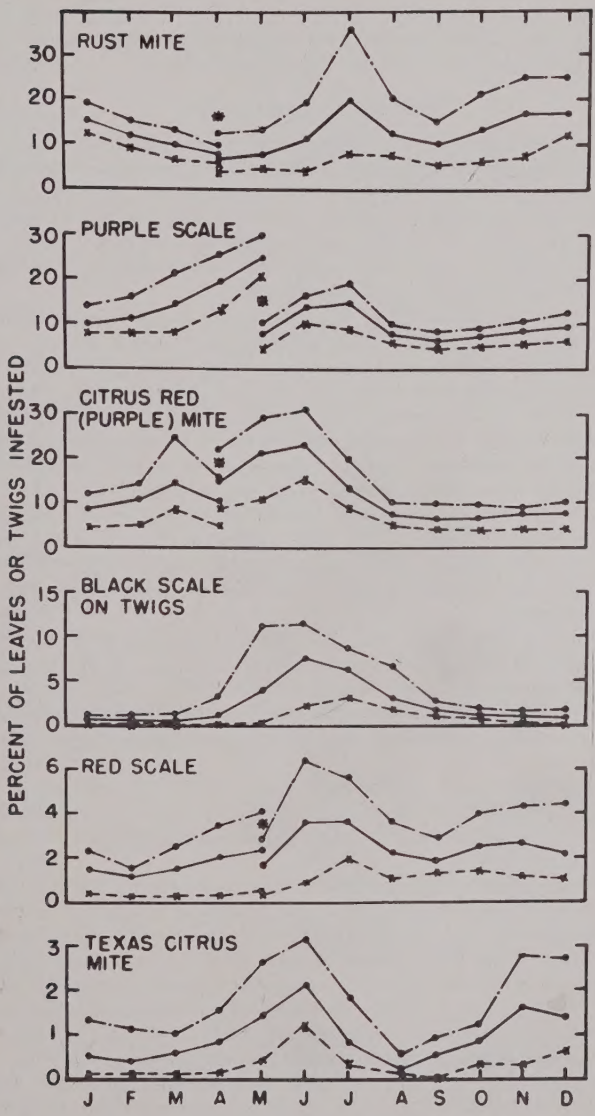
RUST MITE
PURPLE SCALE
CITRUS RED (PURPLE) MITE
BLACK SCALE ON TWIGS
RED SCALE
TEXAS CITRUS MITE
PERCENT OF LEAVES OR TWIGS INFESTED
J F M A M J J A S O N D

Figure 1.—Average, maximum, and minimum abundance of 6 important citrus pests each month during the 8-year period from January, 1951, through December, 1958. The data are from 130 representative citrus groves throughout the Florida citrus belt. An asterisk in the graphs marks the change to observations on spring flush leaves.

the number with class 3 multiplied by 3. The resulting weights were summed and then divided by the total number of groves examined (130) to arrive at the numerical value for population index.

Results and Discussion

The average, maximum, and minimum populations that occurred each month from January 1951 through December 1958 are presented graphically in Figures 1 - 4. Texas citrus mite data, however, are only for the period from July, 1954, through December, 1958. In each chart the solid central line shows the mean of 8 statewide populations observed in each of the 12 months during 8 years. The upper and lower broken lines show the highest and the lowest of the 8 observations.

The graphs are arranged in the same order as the species listing presented earlier in the paper. This arrangement, headed by rust mite, is approximately in descending order of average abundance of the species in commercial groves throughout the year as determined by survey procedures. Thus, all of the graphs have a numerical relationship. The first six species (Fig. 1) are those against which chemical control measures are usually directed and thus are subjected to a more detailed count. Populations of these six principal pests are expressed as percentage of leaves or twigs infested, whereas abundance of the other species is expressed as population index. The data for Texas citrus mite are presented twice, in Fig. 1 as percent leaves infested and in Fig. 3 as population index, to point out the close similarity of the two methods in portraying the seasonal changes.

It should be emphasized that the order of abundance of a species as indicated in this listing is not necessarily its order of importance from an economic standpoint. For example, black scale seldom causes serious losses whereas red scale, which often shows a lower degree of infestation over the state, can build up rapidly in individual groves and cause severe losses.

Weather during the 1951 through 1958 period was probably as typical as for any 8-year period. It included two "dry" years in succession, 1955 and 1956, two "wet" years, 1953 and 1957, and unusually low temperatures in the winter of 1957-58.

The major value of the graphs is that they provide for the first time a measure of "normal" population and delimit a range against which a current population can be evaluated. This is an important aid in the forecasting of citrus pest abundance for control purposes and in studying the effects of weather and other ecological factors responsible for fluctuations. Certain lesser citrus pests are not included in this presentation; among them are pyriform scale, grasshoppers, katydids, pumpkin bugs, and various leaf-feeding worms and beetles.

One phenomenon of interest from a biometric standpoint is the location of the mean population line with respect to the midpoint of the range. Where the mean and midpoint are close together, as is the general situation in all of the 20 graphs, the yearly populations were distributed quite uniformly above and below the mean. Where this is not the case, one limit of the range usually was the result of a highly abnormal population that occurred in only 1 of the 8 years. On the whole, the cycles of rise or decline

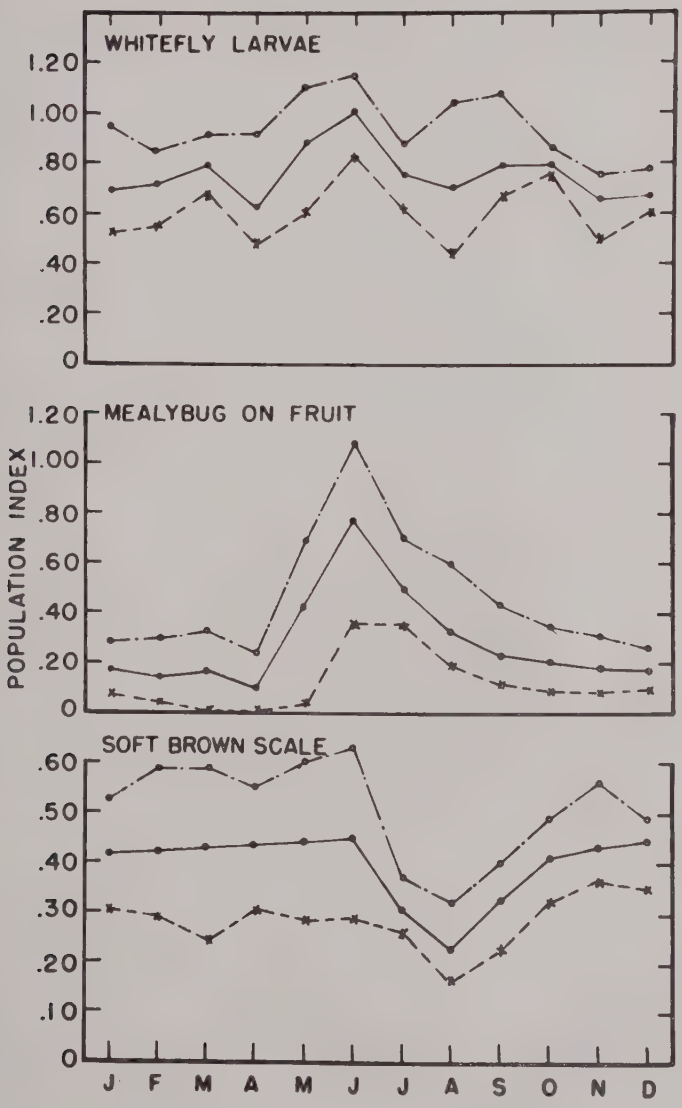

Figure 2.—Average, maximum, and minimum abundance of whitefly larvae, mealybug, and soft brown scale each month during the 8-year period from January, 1951, through December, 1958. The data are from 130 representative citrus groves throughout the Florida citrus belt.

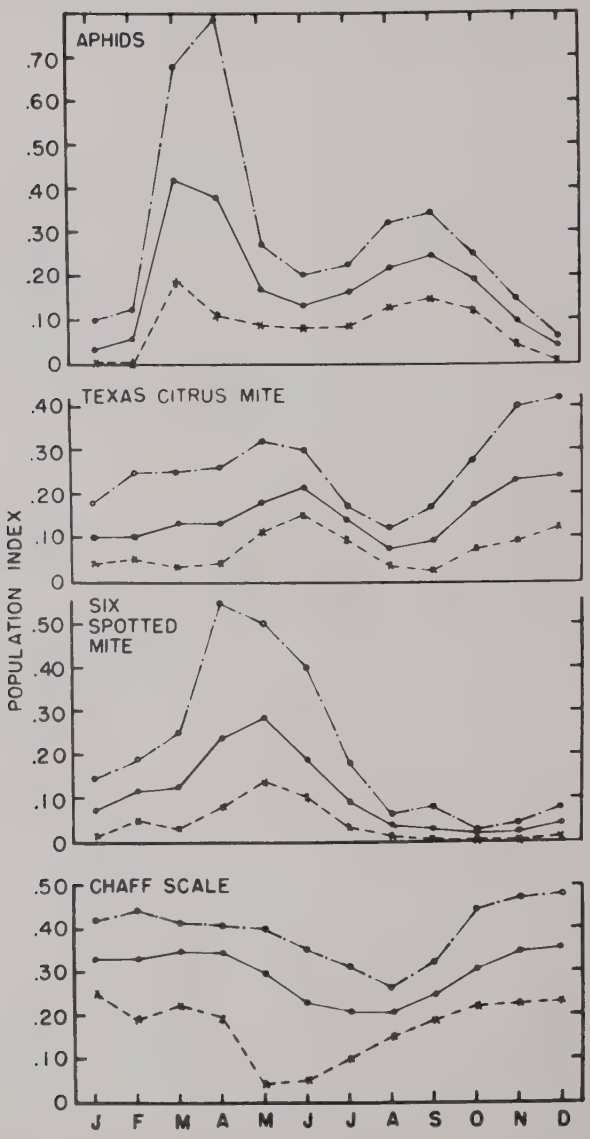

Figure 3.—Average, maximum, and minimum abundance of aphids, Texas citrus mite, six-spotted mite, and chaff scale each month during the 8-year period from January, 1951, through December, 1958. The data are from 130 representative citrus groves throughout the Florida citrus belt.

followed a remarkably similar pattern from year to year. The charts show that each pest has a distinctive cycle which is related to seasonal weather factors and to the growth condition of the host.

Of particular note is the number of species that rather consistently decline to a low level at or near September. Aphids are an exception to this generalization, apparently because their abundance is related to spring and fall flushes of new growth. In the case of whiteflies, the graph shows considerable variability in early fall. At least 3 species of whiteflies, often intermingled, make up the respective infestations reported here and considerable overlapping of broods occurs.

Chaff scale, and to some extent soft brown scale, differ from other scales reported in that their populations decline markedly only during the summer months.

Rust mite, Texas citrus mite, chaff scale, soft brown scale, and fern scale are species that tend to be abundant in late fall as well as at other times of the year. Seasonal information on the Texas citrus mite is of particular interest because of the spread and increase of this species since it was first reported as a citrus pest in 1953 (Muma et al., 1953). The fact that each ensuing year has produced higher populations of this mite implies that future populations may cover a range quite different from that charted through 1958.

Although a period of eight, reasonably representative years may be considered to provide a fair measure of average population levels, it is obvious that the range from maximum to minimum will increase as more years are included in the record. Several notable changes in citrus insect and mite populations occurred in 1958 and in the first half of 1959. These are mentioned specifically in the paragraphs that follow to augment the graphic information.

The purple scale graphs are of special interest because they show that populations of this important citrus pest were always at a relatively high level and did not fluctuate greatly during the 8 years prior to 1959. However, beginning in January, 1959, this species dropped far below the minimum line shown in Fig. 1 and by August, 1959, less than 2 percent of leaves were infested. This extreme reduction in population of a major pest of long standing is believed due to parasitism by *Aphytis lepidosaphes* Compere, which was first noted in Florida groves in 1958 (Muma and Clancy, 1959). Should this parasite continue to be effective in future years, this scale may become much less important. Graphs of purple scale abundance based on the next few years are not likely to resemble those presented here.

Following the unusually cold winter of 1957-58, red scale, purple scale, black scale, citrus red mite, mealybug, and aphid populations were greatly reduced for 2 to 4 months. Much of this effect was a direct result of defoliation of the host. During the late winter and through the spring of 1958, red scale, yellow scale, and mealybug populations were at the minimum points shown on the charts for that period. In this same period, a new maximum was set for chaff scale.

Six-spotted mite also established a new maximum for May and June, 1958. This was expected, since high populations of this mite are favored by cold weather in the preceding December (Pratt, 1955).

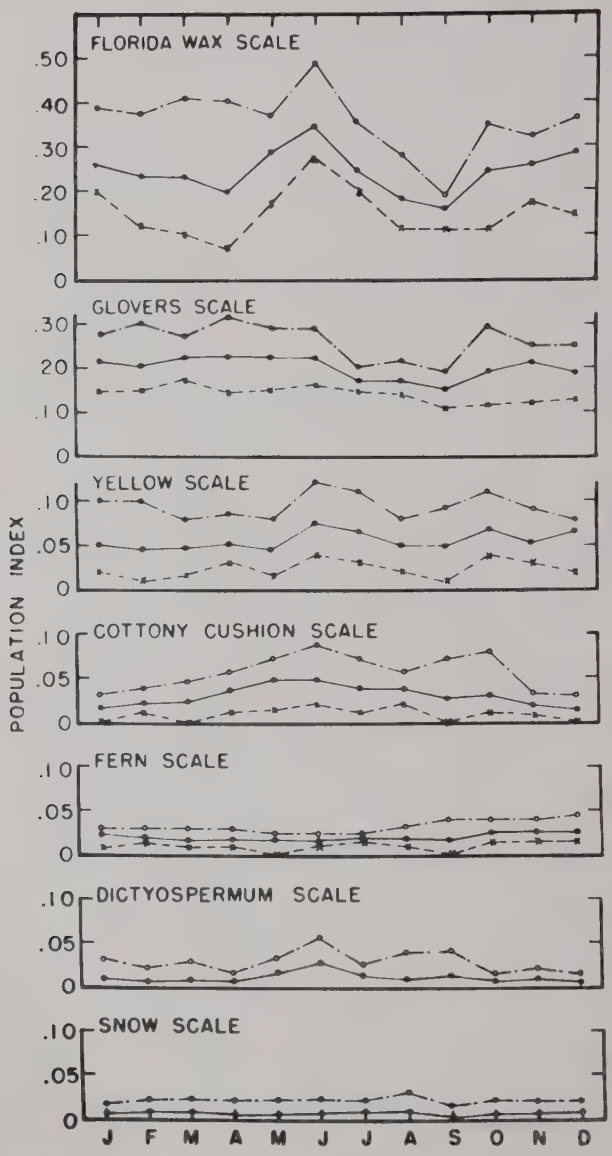

Figure 4.—Average, maximum, and minimum abundance of 7 minor scale pests of citrus each month during the 8-year period from January, 1951, through December, 1958. The data are from 130 representative citrus groves throughout the Florida citrus belt.

It was expected that effects of the cold would extend for many months and this was confirmed early in 1959 when populations of red scale and black scale exceeded the maximums shown by the graphs which were established during the preceding 8 years.

Summary

Populations were determined each month for 19 species of citrus pests in 130 typical commercial groves. The maximum, minimum, and average populations for each month were established by 8 years of observation from 1951 through 1958. These are presented graphically. For many pests, the graphs depict for the first time a measure of "normal" abundance and delimit a probable range of fluctuation.

Each pest exhibited a distinctive cycle of abundance through the season which was repeated with considerable regularity each year. A majority of species reach a high population in early summer and then decline to a low level at or near the month of September. Chaff scale and soft scale decline markedly only during the summer. Rust mite, Texas citrus mite, chaff scale, soft brown scale, and fern scale are species that tend to be abundant in late fall as well as at other times of the year.

Texas citrus mite, first observed as a citrus pest in 1953, has become more abundant in each succeeding year. Purple scale populations during early 1959 were far below the minimum of previous years, apparently due to activity by a new parasite, *Aphytis lepidosaphes* Compere.

Populations of 6 pest species were reduced for 2 to 4 months following the unusually cold winter of 1957-58. Six-spotted mite rose to abnormally high levels during May and June 1958, as expected. Red scale and black scale populations exceeded previous maximums in the first half of 1959.

Acknowledgments

The author wishes to acknowledge with thanks the participation of J. W. Davis, J. K. Enzor, Jr., E. D. Harris, Jr., T. B. Hallam, H. I. Holtsberg, R. M. Pratt, L. M. Sutton, K. G. Townsend, and J. B. Weeks in obtaining the population data included in this paper.

Literature Cited

Muma, Martin H., Harold Holtsberg, and *Robert M. Pratt.* 1953. *Eutetranychys banksi* (McG.) recently found on citrus in Florida (Acarina: Tetranychidae). Fla. Ent. 36(4): 141-144.

Muma, Martin H., and *D. W. Clancy.* 1959. A purple scale parasite new to Florida citrus. Citrus Magazine 21(8): 18.

Pratt, Robert M. 1955. The purple mite and six-spotted mite situation in 1955. Proc. Fla. State Hort. Soc. 68: 31-36.

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FILM-FORMING SPRAYS ON CITRUS IN FLORIDA [1]

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During recent years, chemists, entomologists and plant pathologists have developed effective pesticides from practically all known types of toxic chemicals in both organic and inorganic groups. However, there have been few attempts to determine the value of non-toxic physical barriers applied as coatings for plant protection. The possibility of using materials that are low in toxicity to people as well as insects is especially interesting at this time, when public health authorities are introducing increasingly strenuous controls against the use of highly toxic materials on crops.

The purpose of this study was to determine whether a mechanical film would protect citrus plants from citrus rust mite, *Phyllocoptruta oleivora* (Ashm.), and greasy spot disease.

Since 1955 various plastic, synthetic latex and wax materials, commonly used in industry for paints, binders and water-resistant coatings, have been applied as sprays to determine filming characteristics and effects on citrus plants. Formulations were non-toxic milky-white, aqueous emulsions containing about 50 percent solids. Other characteristics were a particle size of less than 1 micron, a specific gravity of about 1 and pH ranging from less than 3 to more than 9. All of the materials tested mixed with water in all proportions and dried to solid films that would not go back into suspension upon subsequent wetting with water.

PRELIMINARY SCREENING TRIALS

Formulations of polyethylene, acrylic resin, vinyl acetate, wax, polyvinyl alcohol, hydroxyethyl cellulose and other similar materials were applied to fruiting branches. All materials were applied with a compressed air hand sprayer at concentrations of 10 percent of each formulation in water.

Polyethylene formulations were the only phytotoxic materials at concentrations tested. Film deposits of Elvacet, Resin latex WC-130, Plyac, General Chemical Experimental Sticker, General Chemical synthetic wax dispersion and Acetex 2700 became hard and brittle after drying thoroughly. Fruit and foliage coated with Resyn 12-K-55, Rhoplex AC-33, Rhoplex B-15 and Hercules AC-7356 were glossy and the film remained flexible for several months.

In addition to tests with fruiting branches, three types of materials were applied to mature Valencia orange trees. The materials used were: Rhoplex B-15 (Acrylic resin), Plyac (polyethylene) and a suspension of wax. Each material was applied at 2½ percent, 5 percent and 10 percent with a hydraulic grove sprayer operating at about 500 psi. The first application was made in June and a second spray was applied to one-half of each tree in October.

Sprays containing 5 percent or 10 percent polyethylene were phytotoxic to fruit when applied in June, but not in October. The injury produced

[1] Florida Agricultural Experiment Station Journal Series, No. 1057.

was similar to russet caused by citrus rust mite. Good wetting was obtained with the polyethylene spray and a fairly good film was deposited with both concentrations, but the film did not cover the entire fruit and leaf surface and began to weather off after about three months. Applications of wax were not phytotoxic, but began to flake off after about six weeks. Rhoplex B-15 at all concentrations gave a good film which remained pliable for about one year, gave the tree a glossy appearance and apparently had no harmful effect on tree vigor. These results governed the selection of Rhoplex for more extensive replicated trials against specific citrus problems.

Field Tests Against Rust Mite — Methods

In 1958, Rhoplex AC-33 was compared with miticides against rust mite on grapefruit at Fort Pierce and on oranges at Lake Alfred. It was also compared with miticides and fungicides at Fort Pierce for control of greasy spot disease on grapefruit and oranges.

In all experiments, applications were made with a hydraulic grove sprayer equipped with hand guns. Sprays were directed to all parts of the tree and applied to the point of run-off to obtain thorough coverage.

The density of rust mite populations was determined at Fort Pierce by examination of one lens field, with a 10X hand lens, on each surface of 100 leaves in each replicate. Exposed and unexposed surfaces of 25 fruit per plot were examined for rust mite in a like manner at Lake Alfred. If one or more live mites was found, the leaf or fruit was considered infested. Russet fruit determinations were made by examining 10 fruit per tree at Fort Pierce and 25 fruit at Lake Alfred.

The severity of greasy spot disease in the Fort Pierce rust mite experiment was determined by examination of 100 leaves per plot in the following manner: the third leaf from the terminal of current season branches was picked from 25 locations per tree and the severity of disease rated according to the number of lesions per leaf. Ratings consisted of 0, 1, 2 and 3 with 0 representing no lesions, 1 representing 1 to 5 lesions, 2 representing 6 to 15 lesions and 3 representing 16 or more lesions.

Results

In the Fort Pierce rust mite experiment, the percentage of leaves infested with rust mite increased after treatment in check plots, plots sprayed with Rhoplex and in some of the plots sprayed with sulfur, but decreased for at least 21 days after other treatments. However, observations showed that the number of mites on check plants increased in proportion to the percentage of infested leaves. This was not so on Rhoplex-sprayed plants. The Rhoplex film was not continuous over the entire fruit surface and mites were present only in the uncovered areas. Furthermore, the number of mites per lens field on uncovered areas of Rhoplex-sprayed fruit was seldom more than five, while there were usually 15 or more mites per lens field on untreated checks.

Data shown in Table 1 indicated that Rhoplex protected fruit against rust mite injury as effectively as zineb and was superior to sulfur. These data also show that Rhoplex had no harmful effect on fruit color either

TABLE 1.—Percent of Grapefruit Leaves Infested with Rust Mite Before and After Treatment, and Russet Fruit Following Treatment.

Materials and Dosages per 100 Gallons	Percent Infested Leaves on Indicated Dates Before and After Treatments, Applied April 28 and June 23, 1958				Percent of Russet Fruit on Dec. 17, 1958		Average Color Rating	
	4/21 (—7)	5/19 (+21)	6/19 (+52)	7/14 (+21)	Early	Late	Before *	After **
Kepone 25W, 1 lb.	18	7	13	1	13	8	2.2	2.4
Rhoplex AC-33, 5%	17	19	39	38	0	3	2.0	1.7
Zineb 65W, ½ lb.	12	3	21	0	1	8	1.5	2.3
Ethion 47% EC, ½ pt.	24	12	51	38	4	3	1.7	2.0
Sulfur, 10 lbs.	25	27	48	12	30	10	2.2	2.3
Sulfur, 5 lbs.	68	43	57	12	46	5	2.9	3.3
Chlorobenzilate 25W, 1 lb.	30	10	27	3	8	5	2.4	2.3
Check	67	90	60	13	97	10	3.9	4.0
L.S.D. 19:1	18	22	15	8	26			
99:1	25	30	21	11	36			

* Color ratings made before placing fruit in coloring room.
Ratings based on 1 = Good and 4 = Poor; ratings made by seven persons.
** Color ratings made after 72 hours in coloring room (ethylene gas).

TABLE 2.—Percent of Grapefruit Leaves Showing Greasy Spot Disease Lesions on December 17, 1958.

Material and Dosage per 100 Gallons	Percent of Leaves in Each of the Following Groups*			
	0	1	2	3
Kepone 25W, 1 lb.	12	55	22	11
Rhoplex AC-33, 5%	48	37	10	5
Zineb, 65W, ½ lb.	21	53	15	11
Ethion 47% EC, ½ pt.	31	47	12	10
Sulfur, 10 lbs.	28	45	13	14
Sulfur, 5 lbs.	22	43	15	20
Chlorobenzilate 25W, 1 lb.	18	56	15	11
Check	11	27	22	40

* 0 = No lesions.
1 = 1 to 5 lesions.
2 = 6 to 15 lesions.
3 = 16 or more lesions per leaf.
Based on 400 leaves per treatment.

before or during the period when it was degreened with ethylene gas at the packing house.

The severity of greasy spot disease was also recorded in this experiment. Data presented in Table 2 show that Rhoplex controlled greasy spot better than any other material in this test, including zineb and sulfur.

Several mature oranges were dipped in Rhoplex emulsion concentrate to obtain a complete film over the surface of the fruit. These fruit were held at room temperature and compared for keeping quality with fruit sealed in polyethylene bags and with untreated fruit. Untreated fruit and Rhoplex-treated fruit wilted in about three weeks, while fruit sealed in polyethylene bags remained firm for about three months.

In the Lake Alfred experiment, control of rust mite with Rhoplex was significantly inferior to that obtained with either zineb or sulfur. Although Rhoplex was not as effective against rust mite and did not prevent russet as well as zineb or sulfur, it did reduce the severity of rust mite injury to fruit as shown in Table 3.

TABLE 3.—Comparison of Rhoplex, Zineb and Sulphur for the Control of Rust Mite and Fruit Russet on Pineapple Oranges.

Treatment and Dosage per 100 Gallons	Avg. % Fruit Infested with Rust Mite*	Percent Russet Fruit 1-15-59**						Percent Russet-Free Fruit
		Early Russet			Late Russet			
		Light	Mod.	Sev.	Light	Mod.	Sev.	
Unsprayed Check ..	18.1	10.6	9.4	12.4	12.0	5.0	4.0	55.4
Sulfur, 10 lbs.	12.2	5.6	3.6	3.2	5.6	0.8	0.4	83.2
Zineb, ½ lb.	11.8	4.2	3.6	5.0	4.8	2.6	0.6	83.0
Zineb, 1 lb.	11.0	1.6	1.2	1.2	2.0	0.0	0.0	95.2
Rhoplex, 2½%	19.7	7.6	6.8	10.8	10.8	5.4	4.6	59.2
Rhoplex, 5%	16.2	9.2	8.8	8.8	9.0	3.0	0.2	63.8
Rhoplex, 10%	19.0	12.6	6.4	9.4	12.6	3.2	0.0	62.8
L.S.D. 19:1	2.2	2.7	2.3	4.8	2.4	1.3	0.9	9.6
99:1	2.7	3.3	2.8	5.8	3.0	1.6	1.1	12.8

* Average of ten counts made from May 12 to December 30, 1958.
** Treatments applied April 21 and July 30-31, 1958.

Field Tests Against Greasy Spot Disease

Applications of Rhoplex AC-33 were compared with selected agricultural pesticides against greasy spot disease in an experiment at Fort Pierce.

Greasy spot disease accelerates leaf drop in addition to producing characteristic spots on the leaves. In this experiment the severity of greasy spot disease was ascertained by rating trees for density of foliation as well as extent of leaf spotting in a single score for tree condition. An

average rating of 1.0 or less is considered to indicate satisfactory control of greasy spot disease.

Table 4 lists the experimental materials in general order of effectiveness. One pound of tribasic copper sulfate per 100 gallons was the standard treatment with which other treatments were compared. Data in Table 4 show that tribasic copper suflate, Rhoplex AC-33 and mixtures of the two were all satisfactory. However, Rhoplex did not improve control with copper.

TABLE 4.—Comparison of Rhoplex AC-33 with Agricultural Pesticides for the Control of Greasy Spot Disease.

Treatments and Dosages per 100 Gallons	Average Rating for Tree Condition* December 2, 1958	
	Sprayed April 30 and July 1, 1958	Sprayed April 30, 1958
Oil 1.3%	0.0	0.4
Oil 1.3% + Zineb 65W, 2 lbs.	0.0	0.3
Copper 53W, 1 lb.	0.1	0.2
Copper 53W, 1 lb. + Oil, 1.3%	0.1	0.3
Rhoplex AC-33, 5% + Copper 53W, 1 lb.	0.2	0.2
Rhoplex AC-33, 0.5% + Copper 53W, 1 lb.	0.3	0.5
Amobam, 1 qt.	0.5	0.8
Rhoplex AC-33, 5%	0.7	0.7
Niacide Z 65W, 2 lbs.	0.5	0.8
Upjohn U-9547 50W, 1 lb.	0.7	0.8
Fermate 76W, 2 lbs.	0.5	1.0
Actidione Semi-Carbazone 7.7W, 0.5 lb.	0.8	1.2
Griseofulvin 38 gr.	0.8	1.8
Niacide M 65W, 2 lbs.	1.0	1.7
Parathion 15W, 1 lb. + Sulfur WP, 5 lbs.	1.1	1.7
Thylate 65W, 2 lbs.	1.2	1.5
Glyodin 34E, 1 qt.	1.3	1.3
Cyprex 70W, 2 lbs.	1.5	1.2
Actidione 4 ppm. (tablets)	1.5	1.7
Mycostatin 76 gr.	1.7	1.8
Gen. Chem. 1189, 50W, 2 lbs.	2.7	2.0
Check	2.2	2.2

* Tree condition evaluated on the basis of density of foliation and amount of greasy spot shown. Rating scale: 0 = Best tree in the plot; 3 = Poorest tree in the plot. Each rating in the table is the average of individual ratings of at least three trees.

Discussion and Conclusions

One of the problems encountered with plastic sprays was the difficulty of obtaining complete coverage. The success of non-toxic materials of this type depends upon the establishment of a continuous film, a complete barrier between the pest and its food plant. In the experiments reported here, continuous films were not achieved. Nevertheless, sufficiently promising results were obtained to warrant further research with improved formulations.

Notice of the 43rd Annual Meeting of the Florida Entomological Society

The 43rd Annual Meeting of the Florida Entomological Society will be held in Jacksonville at the Robert Meyer Hotel on September 8-9. A pre-meeting "bull session" is scheduled for the evening of September 7. The Secretary has issued a call for papers and members are reminded of the importance of submitting titles and abstracts without delay.

COMPARISON OF INSECTICIDES, INSECT PATHOGENS AND INSECTICIDE-PATHOGEN COMBINATIONS FOR CONTROL OF CABBAGE LOOPER *TRICHOPLUSIA NI* (Hbn.)[1] [2]

WILLIAM G. GENUNG[3]

The recent increased interest in the use of pathogenic agents, particularly bacterial and polyhedrosis diseases, for insect control has largely resulted in tests that compared the pathogens only with untreated checks. A few trials included a standard insecticide treatment (Rabb et al 1957), but investigations of combinations of pathogens and insecticides appear to be hardly pioneered. McEwen and Hervey (1958) used an aphicide (TEPP) with a polyhedrosis virus to observe the effect of the insecticide on the virus. The data presented indicated that this weak larvicide did not add to the mortality percentage obtained with the pathogen alone.

The practical use of these virus and bacterial diseases is hampered by considerable specificity, even among those most generally pathogenic. The host range varies from a single host species to a few usually fairly closely related species or genera, which is a narrow spectrum of activity when compared with most modern insecticides. However, most crops are attacked by a wide range of insects belonging to several orders, which vary from almost complete susceptibility to no susceptibility to a particular organism. Hence, it seemed desirable to compare combinations of pathogenic agents and insecticides with these two control methods used alone. It appears that such an approach may be needed to interest growers in some areas in microbial agents as a practicable component in the insect control arsenal. Steinhaus (1957) discussed the harmlessness of these pathogens to man and more recently (1959) discussed the improbability of *Bacillus thuringiensis* Berliner mutating to forms dangerous to vertebrates. Certain similarities between this species and *Bacillus anthracis* Cohn had caused some concern.

The object of this investigation was to compare pathogens, insecticides, and pathogen-insecticide combinations for the control of lepidopterous larvae attacking cruciferous crops, and particularly the cabbage looper, *Trichoplusia ni* (Hbn.). Various workers in different parts of the United States have discussed the difficulty of controlling this species in recent years, Genung (1955), Hall (1957), McEwen and Hervey (1958), and McEwen and Hervey (1958, 1959) showed that a polyhedrosis virus had possibilities for control of the cabbage looper. Tanada (1956) and Hall and Dunn (1958) reported that cabbage looper is not as susceptible to *Bacillus thuringiensis* Berliner as are a number of other larvae, and that a relatively high spore concentration is required to give a reasonable degree of control.

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[1] Florida Agricultural Experiment Station Journal Series, No. 1050.

[2] Mr. C. E. Seiler, Field Assistant was helpful in various aspects of the work. Mr. Edward King, Jr., Draftsman, and Mr. H. P. Ruffolo, Staff Assistant, prepared the graphs.

[3] Associate Entomologist Everglades Experiment Station, Belle Glade, Florida.

Experimental Procedure

Collards, *Brassica oleracea* var. *acephalica* L., was selected as the test crop since it supports large populations of loopers and other caterpillars. Only the cabbage looper occurred in this experiment except for a trace population of imported cabbage worm, *Pieris rapae* (L.). A randomized complete block design experiment was employed and treatments were replicated five times. The plots were four rows wide (36 inches between rows) and 25 feet long. There was a 12-foot buffer zone between plots and blocks. Emulsifiable concentrates of 4 insecticides were used. The amounts per acre of each material when used alone was as follows: Toxaphene 2.00 lbs., Phosdrin 0.25 lbs., Guthion 0.375 lbs., Dimethoate 0.50 lbs. The source of the native polyhedrosis virus studied was from looper cadavers collected the previous summer and stored at room temperature in a pint jar. When the test was started the liquified loopers were measured in milliliters and an equal amount of distilled water added to form a stock solution. This material was used at a rate of 60 milliliters or 1.6 x 10^{9} polyhedra per 100 gallons of spray per acre. A standard chemical insecticide for looper control (toxaphene) was used in combinations with both the virus and with the *Bacillus*. Both the insecticide and the pathogenic agents in the combinations were used at one-half the dosage when used alone. Triton B-1956 spreader-sticker was added to all the spray mixtures. A formaldehyde solution was used to disinfect equipment to avoid possible accidental contamination of plots. Materials were applied with a self-propelled spray rig [Harrison et al (In press)] at a rate of 100 gallons per acre and 250 p.s.i.

An application was made when the plants were about 18 inches tall. However, plants were overlapping in the row middles, so that good coverage was difficult.

Evaluation of looper control was made by a count of surviving loopers on 10 leaves per plot at 5 and 7 days after application. Data collected at 14 days consisted of larval injury to the foliage. The number of holes exceeding 1/16 inch in diameter per ten-leaf sample was recorded. The last count was based on damage because more than a week of hot, humid weather with heavy rainfall had resulted in considerable reduction of loopers through natural appearance of the polyhedrosis epizootic. Genung (1951) has discussed the rapidity of movement of this natural infection under Everglades conditions.

Results

The results of this experiment are shown graphically in Figure 1.

Five day count: All treatments were significantly better than phosdrin. The toxaphene-polyhedrosis virus combination and Bacillus-toxaphene combination gave the lowest count of surviving larvae but these treatments were not significantly better than either toxaphene or the Bacillus used alone. Apparently the polyhedrosis virus used alone had attained only partial effectiveness 5 days after application as it resulted in a higher number of surviving loopers than all treatments except phosdrin. Unrecorded observations made at 48 hours after treatment indicated that Dimethoate, Phosdrin and Guthion gave adequate initial knockdown but

did not have enough residual activity against the large population in the experiment.

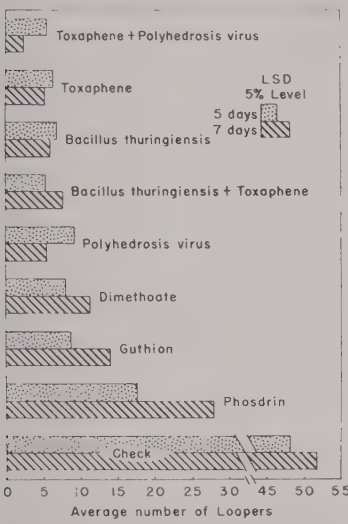

Figure 1. Comparative effectiveness of the insecticides, pathogens, and insecticide-pathogen combinations at 5 and 7 days after application, based on larval count.

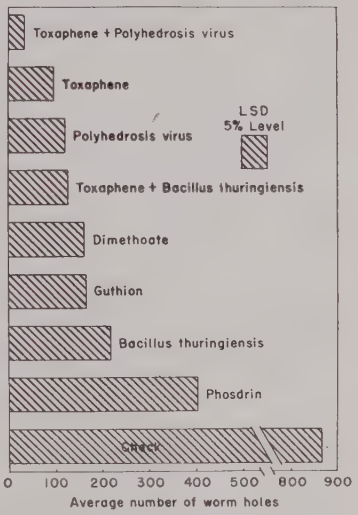

Figure 2. Comparative effectiveness of the treatments at 14 days from application, based on amount of leaf injury.

Seven day count: Although the population continued to rise in the checks and in the phosphatic treatments the number of loopers declined in the polyhedrosis-toxaphene combination, toxaphene, polyhedrosis, and Bacillus treatments. The toxaphene-polyhedrosis virus combination gave a lower count in all replicates but was not significantly better than toxaphene, polyhedrosis virus, or the Bacillus. However, it was significantly better than the Bacillus-toxaphene combination.

Fourteen day count: Since the data for this count were based on injury and therefore cumulative, perhaps it is not exactly comparable with the two previous (larval) counts. However, it parallels and quite closely compliments the two larval counts. The data showed the polyhedrosis-toxaphene combination to be significantly better than all other treatments. Toxaphene, polyhedrosis virus, and the Bacillus-toxaphene combination approached the effectiveness of the virus-toxaphene combination. The Bacillus used alone apparently had shown its maximum effect and began declining sometime between the 7- and 14-day counts. For looper control it would possibly need to be applied with the regularity of a chemical insecticide. On the other hand the polyhedrosis virus maintained itself longer, indicating that a localized epizootic was initiated. As might be anticipated, the data indicated that there was a direct relationship between interval from application and effectiveness of the phosphatics (Figure 2).

Discussion

Although organisms and insecticides in combination were used at only half the amounts of each material when used singly, it was indicated that a control program might be considerably improved by such combinations. However, other insecticides might not indicate the degree of compatibility shown by toxaphene when combined with these organisms and a need for such testing is indicated. The polyhedrosis virus-toxaphene combination was particularly outstanding and gave a consistently lower count than either component at double the dosage. When used alone the organisms compared favorably with the chemicals in normal use.

For best results, good coverage with insect pathogens is probably almost as essential as with a chemical insecticide. Had it not been for the extreme density of the foliage in these plots better control with all treatments might have been obtained.

If it can be assumed that an individual not killed by an insecticide would become infected, then it would appear that the combined use of insecticides and pathogens would tend to slow the development of resistance to insecticides.

Literature Cited

Genung, W. G. 1951. Fla. Agr. Expt. Sta. Annual Report for 1951: 183.

Genung, W. G. 1955. Fla. Agr. Expt. Sta. Annual Report for 1955: 241.

Hall, Irvin M. 1957. Use of a polyhedrosis disease to control cabbage looper on lettuce in California. Jour. Econ. Ent. 50 (5): 551-553.

Harrison, D. S., W. G. Genung, and *E. D. Harris.* 1959. A small self-propelled sprayer for agricultural research. Fla. Ent. 42 (4):169.

Hall, Irvin M., and *P. H. Dunn.* 1958. Susceptibility of some insects to infection by *Bacillus thuringiensis* Berliner in laboratory tests. Jour. Econ. Ent. 51 (3): 296-298.

Hervey, G. E. R., and *K. G. Swenson.* 1954. Effectiveness of DDT for cabbage looper control in western New York 1944 and 1953. Jour. Econ. Ent. 47 (4): 564-567.

McEwen, F. L., and *G. E. R. Hervey.* 1958. Control of cabbage looper with a virus disease. Jour. Econ. Ent. 51 (5): 626-631.

McEwen, F. L., and *G. E. R. Hervey.* 1959. Microbial control of two cabbage insects. Jour. Insect Path. 1: 86-94.

Rabb, Robert L., Edward A. Steinhaus, and *Frank Guthrie.* 1957. Preliminary tests using *Bacillus thuringiensis* Berliner against hornworms. Jour. Econ. Ent. 50 (3): 259-262.

Steinhaus, Edward A. 1957. On the harmlessness of insect pathogens. Jour. Econ. Ent. 50 (6): 715-720.

Steinhaus, Edward A. 1959. On the improbability of *Bacillus thuringiensis* Berliner mutating to forms pathogenic for vertebrates. Jour. Econ. Ent. 52 (3): 506-508.

Tanada, Yoshinori. 1956. Microbial control of some lepidopterous pests of crucifers. Jour. Econ. Ent. 49 (3): 320-329.

THE PERFORMANCE OF DDT FOR CORN EARWORM CONTROL OVER AN ELEVEN YEAR PERIOD [1]

JOHN W. WILSON
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Since resistance of the house fly to DDT was reported in 1947, additional reports of resistance of other insects continue to appear in the literature. At present insects attacking vegetable crops reported to be developing resistance to insecticides include the imported cabbage worm (McEwen and Chapman, 1952), the cabbage looper (Reid and Cuthbert, 1957), the southern wireworm (Reid and Cuthbert, 1956), and the serpentine leaf miner (Wolfenbarger, 1958). The increased interest during recent years in this subject of resistance has stimulated the compilation of the data presented in this paper. These data represent results from the use of DDT dust and 25 percent DDT emulsifiable formulations taken from experiments which included other insecticides. The experiments were conducted each spring from 1949 through 1959 at the Central Florida Experiment Station at Sanford, Florida.

METHODS AND MATERIALS

The cultural practices recommended for central Florida were followed. These included land preparation and soil fumigation for nematode control, a between-the-row spacing of 30 inches and an in-the-row spacing of 12 inches with a single plant in each hill, and 3000 pounds per acre of 5-5-8 or equivalent fertilizer, with 500 pounds per acre applied in the row prior to seeding and the remainder in three equal applications as side dressing at fourteen day intervals. Usually an additional side dressing was applied at tassel appearance consisting of 200 to 300 pounds per acre of nitrate of soda. Shallow cultivation for weed control was practiced at irregular intervals as required.

The plots treated with emulsifiable formulations were 4 rows wide in 1949 as was the case for both dust and liquid formulations in all of the other years. The plots were 60 feet long, with 15-foot alleyways between blocks. There were 4 replicates with the treatments arranged in a simple random pattern in each block. In most years different plantings made on the same date of the same sweet corn variety were used for the dust and emulsifiable formulations. For this reason the data for the two types of formulations are not statistically comparable.

In 1949 the plots treated with dust formulations were 6 rows wide to accommodate a six-row power duster. Because of the difficulty of cleaning this machine between treatments, rotary type hand dusters were used all other years. The discharge outlet of both the machine and hand dusters were held slightly above the silks of the upper ears and the duster passed down one side of each row at each application. An attempt was made to apply the dusts at the rate of 30 pounds per acre, but in actual practice

[1] Florida Agricultural Experiment Station Journal Series, No. 1006.

TABLE 1.—Pounds of DDT and Gallons of Mineral Oil per Acre Applied During Each of the Eleven Years.

Years	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
Pounds Actual DDT/Acre/Application in Dust Formulation	2.2	2.0	2.95	1.86	1.97	1.75	1.60	3.16	2.44	2.51	4.17
Pounds Actual DDT/Acre/Application in Emulsifiable Formulation	2*	1.75	1.40	2.45	2.0	2.0	2.0† & 2.5	2.0	2.5	1.75† & 2.5	2.00† & 2.25
Gallons/Acre/Application Mineral Oil Added		2.5	2.0	3.0	2.5	2.5	1.75† & 0	1.0	0	1.75† & 0	1.75† & 0
Gallons Diluted Spray per Acre Application		50	80	140	100	80	30	75	50	60	80

* DDT mixed with mineral oil and applied to silks when wilted.
† Two treatments, the first DDT in combination with mineral oil and the second DDT alone.

the amount applied varied from 20 to 50 pounds per acre. The figures given in Table 1 were obtained by weighing the duster before and after each application and are averages for the year.

The same power sprayer was used during the entire period. It was equipped with a four-row boom having 2 nozzles on each side of the row, arranged in such a manner that one nozzle was directed at the silks of the upper ear and the other nozzle at the lower ear. At the beginning of each corn spray season new disks having an orifice of 0.041 inch were placed in the spray nozzles and the amount of liquid being applied per acre was determined (Table 1).

A laboratory mixed preparation was used for the 1949-1952 experiments with dust formulations. A 50 percent wettable powder was used as the source of DDT and Pyrax was used as the diluent. The dust was mixed in a Day Laboratory Mixing Machine. For 1953 to 1959 inclusive commercially prepared dust mixtures were used while in 1951 and 1952 a laboratory prepared emulsifiable concentrate was used. The concentrate was prepared using the following formula (all proportions are by weight); 25 percent DDT (setting point 89° C.), 72 percent Xylene and 3 percent Triton X155. For the other years commercially prepared 25 percent emulsifiable DDT was used as the source of DDT for the spray treatments.

In all years applications of the insecticides were started the day after the first silks were observed. The interval between applications varied from year to year. These intervals are given in Table 3. In most cases approximately 10 per cent of the ears were estimated to be in silk by the second day of silking. Beginning in 1954 and each year thereafter daily counts were made of the percent of upper ears in silk, until 100 percent of these ears were in silk. A summary of these data is presented in Table 2. The dust formulations were applied beginning about 6:00 A.M. to take advantage of the relatively calm portion of the day. The spray formulations were usually applied between 8:00 A.M. and noon.

Table 2 also gives the number of days rainfall occurred and the total amount in inches of rainfall during the spray period. Sometimes rain fell shortly after the insecticides had been applied. When this occurred the applications were made again the next day. When the rain occurred during the day following the scheduled application, the insecticides were applied the next scheduled day for application of the insecticides.

At harvest time all of the upper ears of the two center rows of each plot were harvested and weighed in the husk. The recorded weights of the unhusked ears are not included as a part of the presented data, because differences in weights of corn from the treated and untreated plots were not statistically significant. This was interpreted to mean that the insecticides did not adversely affect the yields of corn.

After the weights were recorded, 50 ears from each plot were husked and examined for earworm injury. These ears were divided into two classes, uninjured and injured. The degree of injury was not considered in the evaluation of the insecticides. From these records the percent of worm-free ears was calculated. These percentages were the basis upon which the insecticides were evaluated.

TABLE 2.—Duration of the Period Required for 100 Percent of the Upper Ears to Produce Silks and Rainfall Data.

Years	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
Days from First Silks to 100% Ears in Silk						8	*	12	12	13	12
Number Days Rain Fell During Spray Period	0	0	0	0	0	0	0	3	8	7	9
Total Amount of Rainfall in Inches During Spray Period	0	0	0	0	0	0	0	0.74	4.65	1.43	2.70

* Counts made on two days only with 58 percent of ears in silk the day the first application was made.

Results and Discussion

A description of some of the factors affecting the growth of the corn plant has been given in some detail in the preceding section. Such factors as land preparation, nematode populations, fertilization, cultural practices, and weather conditions throughout the growing period affect the uniformity of stand and growth rate. Harris (1958) has presented data showing that the degree of earworm damage in varietal trials is affected by the uniformity of the stand. The rate of growth in turn affects the time required for all of the ears to produce silks. Soil and atmospheric moisture and atmospheric temperatures affect the duration of the period the silks are attractive to ovipositing earworm moths. Thus, every effort should be made to grow the corn uniformly and rapidly to reduce the length of time the ears are exposed to earworm attack.

Results are recorded in Table 3. A very high degree of control was obtained in 1949 with both the 5 and 10 percent dust formulations applied to the corn harvested April 18. Poor control was obtained with the 5 percent DDT dust in all cases where it was used, except in the early planting of 1949 when a very low earworm population was present and in 1953 in the presence of a high earworm population (1 percent worm-free ears from the untreated plot). Sweet corn growers were using 10 percent DDT dust in 1949. At the present time almost all of the growers use a 10 percent DDT dust or dust combinations of DDT with parathion or chlordane. This is readily understood when the data in Table 3 are examined. All of the Florida sweet corn is produced for the fresh market which requires a U. S. Fancy grade (no wormy ears allowed). Attention should also be directed to the fact that higher degrees of control are obtained in commercial fields than appears to be possible in small experimental plots.

The degree of control obtained with both the dust and emulsifiable formulations in 1957 and 1958 is lower than that obtained in other years. The control obtained by both formulations is somewhat erratic when the entire eleven-year period is considered. The reasons for these variable results are not clear at this time.

Summary

Data obtained over an eleven-year period on some of the factors affecting earworm control and results from applications of DDT dust and emulsifiable formulations are presented. These data indicate that, if dust formulations are to be used, a 10 percent DDT dust is required to give a satisfactory control. In 1951, good control was obtained with 3 quarts of 25 percent emulsifiable DDT plus mineral oil in an early planting and poor control in a later planting. In 1953, 1955, and 1959, 4 quarts of 25 percent emulsifiable DDT plus mineral oil produced good results. In 1956 and 1959, 5 quarts of 25 percent emulsifiable DDT gave a good control while the same treatment was considerably poorer in 1954, 1957, and 1958. These data indicate that the control with both formulations was erratic. Although poor control was obtained with both the dust and emulsifiable formulations in 1957 and 1958, the data do not indicate that the corn earworm is developing resistance to DDT.

TABLE 3.—Results from the Use of DDT for Corn Earworm Control in Central Florida Over an Eleven Year Period.

Years	1949		1950	1951		1952	1953	1954	1955	1956	1957	1958	1959
Date Corn Harvested	4–18	5–31	5–19	5–23	6–11	6–12	5–24	5–25	6–14		5–29	6–11	6–5
Variety	Ioana		Ioana	Ioana	Calumet	Ioana	Ioana	Ioana	Calumet	Calumet	Calumet	Calumet	Calumet
Number Applications	5	5	5&3**	6	7	7&5	11†&7†	10&6	6	8	8†	11‡	10†
Interval Between Applications, Days	4	4	3	2	2	2&3	1 &2	1&2	2	2	2	2	2
						Percent Worm Free Ears Harvested							
3% DDT Dust		10	10										
5% DDT Dust	95	15	44	50	9	6	93	81					
10% DDT Dust	99							97	91		52	68	89
Untreated	84	8	11	4	2	0	1	8	23		2	4	29
3 qts. DDT + Mineral Oil		39*	76††	90††								86††	
4 qts. DDT + Mineral Oil						47	92	72††	90††				98††
5 qts. DDT								76		90	82	74	95
Untreated		8	11	4	2	0	1	3	10	0	0	0	29

* One application by hand applicator to silks when wilted.

** Where the number of dust and spray applications differed the number of dust application is first in every case.

† One application repeated 24 hours after previous application because of rain.

†† See Table 1 for exact dosages of DDT and mineral oil.

‡ Two applications repeated at 24-hour intervals because of rain.

LITERATURE CITED

Harris, Emmett D., Jr. 1958. Factors affecting the results of corn earworm control studies. Fla. Ent. 41:2: 51-60.

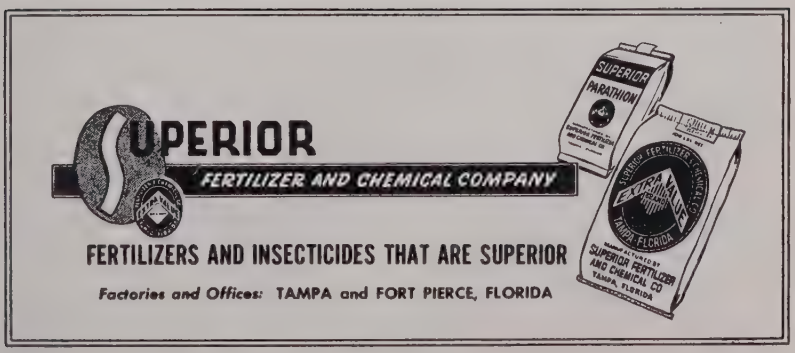
McEwen, F. L., and *R. Keith Chapman.* 1952. Imported cabbage worm resistance to insecticides. Jour. Econ. Ent. 45:4: 717-722.

Missiroli, A. 1947. Riduzione O eradicagione degli anofeli. Riv. di Parassitol. 8: 141-169.

Reid, W. J., Jr., and *F. P. Cuthbert.* 1956. Resistance of the Southern potato wireworm to insecticides. Jour. Econ. Ent. 49:6: 879-880.

Reid, W. J., Jr., and *F. P. Cuthbert.* 1957. Control of caterpillars on commercial cabbage and other cole crops in the South. U. S. D. A. Farmers Bul. 2099.

Wolfenbarger, D. O. 1958. Serpentine leaf miner: brief history and summary of a decade of control measures in South Florida. Jour. Econ. Ent. 51:3: 357-359.



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TABANIDAE ATTRACTED TO AN ULTRAVIOLET LIGHT TRAP [1]

DARRELL W. ANTHONY [2]

The development of new types of lamps in the last few years has renewed interest in the use of light traps for insect surveys. Glick and Hollingsworth (1954, 1955, 1956) showed that lights emitting energy in the near ultraviolet and visible regions of the electro-magnetic spectrum were attractive to adults of the pink bollworm (*Pectinophora gossypiella* [Saund.]), and that such lights were valuable for insect surveys. Merkl and Pfrimmer (1955) found that other cotton pests were also attracted to ultraviolet light.

Ultraviolet, or black, light traps have been used principally for surveys of lepidopterous pests; thus there have been few references indicating that such lights were attractive to Diptera. Pfrimmer (1955) recorded rather large numbers of Diptera taken during the early months of the year, but he did not list family response within the order. In studies with different types of ultraviolet lamps and trap designs, Frost (1957) listed eight families of Diptera as well as "midges" and "miscellaneous Diptera," but made no mention of the Tabanidae. Tabanids have been reported from New Jersey light-trap collections. MacCreary (1940) reported 10 species from this type of trap in Delaware, and Frost (1953) recorded 19 species in Pennsylvania. Apparently the first indication that tabanids were attracted to ultraviolet was that given by Hetrick (1955), who reported 25 families of Diptera from collections in Florida.

The collections recorded here were made by L. A. Hetrick at his residence in Gainesville, Florida. The commercially built omnidirectional trap is similar in design to the Pennsylvania No. 1 trap described by Frost (1957). The light source was a 15-watt GEBL fluorescent lamp that radiated energy in the near ultraviolet region (2,800-3,800 angstroms). The lamp was mounted vertically between four baffles. The light and baffle unit was constructed over an 18-inch funnel that tapered to 3 inches at the lower end and was fitted with a plastic cup. It was supported on a metal tripod.

The trap was operated primarily for the accumulation of teaching material at the University of Florida. The operation hours were from about 15 to 30 minutes before dark until 10 to 10:30 p.m., depending upon early evening temperatures and other weather conditions. As the collections were usually stored for several months before use, all the specimens were killed and preserved in 70-percent isopropanol. At first it was believed that wet preservation would interfere with their identification; however, most of the flies were easily pinned and when dry they could hardly be differentiated from dry-killed pinned specimens.

The first group of tabanids examined was an accumulation of specimens separated from trap collections made during the summer months from

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[1] The research for this paper was done while the author was attending the University of Florida.

[2] Entomology Research Division, ARS, U.S.D.A.

1954 through 1958. The flies were removed from the preservatives, pinned, and allowed to dry 24-48 hours before determinations were attempted. A list of the species [3] and the sexes represented is given below.

SUBFAMILY TABANINAE

Chlorotabanus crepuscularis (Bequaert)	♂ ♀
Diachlorus ferrugatus (Fabricius)	♀
Leucotabanus annulatus (Say)	♂
Tabanus aar Philip	♀
americanus Forster	♂ ♀
atratus Fabricius	♀
gladiator Stone	♂ ♀
gracilis Wiedemann	♀
imitans Walker	♀
imitans excessus Stone	♂ ♀
johnsoni Hine	♀
lineola Fabricius	♂ ♀
melanocerus Wiedemann	♀
nigripes Wiedemann	♂ ♀
pumilus Macquart	♂
stygius Say	♀
sulcifrons Macquart	♂
zythicolor Philip	♂ ♀

SUBFAMILY PANGONIINAE

Chrysops flavidus [*i.e. flavidus*] Wiedemann	♂ ♀
flavidus reicherti Fairchild	♀
montanus perplexus Philip	♂

The second group consisted of the specimens attracted to the ultraviolet-light trap between April 23 and July 31, 1959.

SUBFAMILY TABANINAE

	♂	♀
Chlorotabanus crepuscularis	12	9
Diachlorus ferrugatus	0	2
Tabanus aar	0	3
americanus	1	0
fumipennis Wiedemann	2	0
gladiator	1	2
gracilis	0	1
imitans	0	2
lineola	43	9
melanocerus	1	1
nigripes	2	3
zythicolor	0	1

[3] Alan Stone, Entomology Research Division, U.S.D.A., assisted in the identification of some specimens.

Subfamily Pangoniinae

Chrysops flavidus	0	2
vittatus floridanus Johnson	0	1
Total	62	36

Tabanus lineola was the predominant species in both these collections, the males outnumbering the females by nearly 5 to 1 in the latter group. *Chlorotabanus crepuscularis* was next in abundance in 1959, but this species was represented by only a single specimen from 1954 through 1958. Of the 14 species and subspecies and 98 specimens collected in 1959, only 37 percent were females. This figure is obviously influenced by the high ratio of *lineola* males. As the males of some species are difficult to collect, it may be significant that of the total of 23 species and subspecies taken from the trap, males of 14 species were present. In 1959 the individual species appeared in the traps at about the same time as the expected period of adult activity.

The number of tabanids attracted to the trap was small, probably no more than 0.001 percent of the total insect catch. In the period 1954 through 1958, only 133 specimens were taken but they were separated from the collections by students and it is possible that many specimens were overlooked or purposely discarded. This assumption is further supported by the collection of 98 horse flies and deer flies from the trap between April 23 and July 31, 1959. It is believed that only a small percentage of the tabanids attracted to the light become trapped in the plastic cup. Some of the specimens reported here were taken from the baffles, fluorescent tube, or the funnel of the trap. The yield of tabanids could probably be considerably increased by careful observation of the trap during operation.

Summary

Twenty-three species and subspecies of tabanids divided among five genera and two subfamilies were recorded from two groups of ultraviolet-light trap collections in Gainesville, Florida, one in 1954 through 1958 and the other in 1959. Males of 14 species and subspecies were present in the collections. *Tabanus lineola* was the predominant species, followed by *Chlorotabanus crepuscularis*. In the 1959 collections, the males of *lineola* outnumbered the females by nearly 5 to 1. Of a total of 98 specimens attracted to the ultraviolet light trap during 1959, only 37 percent were females.

Literature Cited

Frost, S. W. 1953. Tabanidae attracted to light. Ann. Ent. Soc. Amer. 46(1): 124-125.

Frost, S. W. 1957. The Pennsylvania insect light trap. Jour. Econ. Ent. 50(3): 287-292.

Glick, P. A., and *J. P. Hollingsworth.* 1954. Response of the pink bollworm moth to certain ultra-violet and visible radiation. Jour. Econ. Ent. 47(1): 81-86.

Glick, P. A., and *J. P. Hollingsworth.* 1955. Response of moths and other cotton insects to certain ultra-violet and visible radiation. Jour. Econ. Ent. 48(2): 173-177.

Glick, P. A., and *J. P. Hollingsworth.* 1956. Further studies on the attraction of pink bollworm moths to ultra-violet and visible radiation. Jour. Econ. Ent. 49(2): 158-161.

Hetrick, L. A. 1955. The use of ultra-violet light for obtaining insect specimens for use in teaching. Entomological Society of America.

MacCreary, D. 1940. Report on the Tabanidae of Delaware. Delaware Agr. Expt. Sta. Bull. 226, 41 pp.

Merkl, M. E., and *T. R. Pfrimmer.* 1955. Light trap investigations at Stoneville, Mississippi, and Tallulah, Louisiana, during 1954. Jour. Econ. Ent. 48(6): 740-741.

Pfrimmer, Theodore R. 1955. Response of insects to three sources of black light. Jour. Econ. Ent. 48(5): 619.

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SOME OBSERVATIONS ON THE BIOLOGY OF *ANCHYLOPERA PLATANANA* CLEMENS (LEPIDOPTERA, OLETHREUTIDAE) IN FLORIDA [1] [2]

H. A. DENMARK [3]

Anchylopera platanana Clemens, a well-known planetree [4] feeder, was found eating the leaves of planetrees by the writer in the Gainesville area in the summer of 1958. This was the first report of this insect in Florida in the State Plant Board records.

Clemens (1860) first described the insect and gave the type locality as Pennsylvania and the host plant as planetree. He indicated two possible generations a year in Pennsylvania. This insect was later described by Zeller (1875) as *Phoxopteris marcidana*, by Walsingham (1884) as *Phoxopteris platanana* and by Fernald (1903) as *Ancylis platanana*. Other distribution records given by Mackay (1959) are Arkansas, District of Columbia, Illinois, Maryland, Missouri, New Jersey, New York, Ohio, Virginia, West Virginia and Grand Bend, Ontario, Canada. She illustrates the larval stage and gives the width of the head capsule of the last instar of two larvae as 0.66 mm. and 0.88 mm. A life history study and some observations on the biology of *A. platanana* were made in the Gainesville area during the summer and fall, 1958, and the spring, summer and fall, 1959.

FIELD OBSERVATIONS

As far as is known this insect is host specific to planetree. The planetrees on the campus of the University of Florida, probably the largest planting in Alachua County, were almost all heavily infested in the summer and early fall of 1958. There were local heavy infestations with light general infestations in the Gainesville area in 1959.

After the initial find of *A. platanana* in June, 1958, weekly observations were made in the vicinity of Gainesville. By July it was evident that this was a multibrood insect with overlapping generations. Although most of the planetrees had shed their leaves by November 1, adults were present and attracted to light in the evenings. No adults were observed at light after November 16, 1958, and in 1959 no adults were seen at planetrees or at lights after October 14, although almost half of the leaves remained on some of the trees. The prepupa, the overwintering stage, could be found in fallen leaves both years.

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[1] Contribution No. 4, Entomology Department, State Plant Board of Florida, Gainesville, Fla.

[2] This report was part of a graduate problem course in the Department of Entomology, University of Florida, 1958 and 1959.

[3] Chief Entomologist, State Plant Board of Florida, Gainesville.

[4] "Sycamore is the forestry name for this genus and is also, unfortunately, strongly entrenched in American usage. Sycamore (meaning 'Fig Mulberry' or rather 'Mulberry Fig') is a patent misnomer for the genus *Platanus*, and has arisen from a similarity in leaf shape to the 'Sycamore' of the Bible." Harlan P. Kelsey and William A. Dayton. 1942. *Standardized Plant Names* Second Edition. J. Horace McFarland Co., Harrisburg, Pa., p. 612.

Two adults (1♂,1♀) were flushed from the grass beneath a planetree on the University of Florida campus on March 13, 1959. The female was examined and eggs were found in which embryos were beginning to develop. A second female was caught on the side of a building in Gainesville after a rain in the afternoon of March 19.

Buds on planetrees began opening March 18 in the Ocala area and March 25 in the Gainesville area. Planetrees on the campus of the University of Florida were checked twice a week for *A. platanana* following the formation of leaves April 1. The first infestation with first and second instar larvae was found on April 13 near the sewage disposal plant on the campus of the University. A second infestation was found April 25, and a third infestation was found May 2, both in the Gainesville area. The three infestations were in areas where some of last year's leaves could still be found. This was especially true of the area around the sewage disposal unit. Pipes were stacked near a twenty-five foot planetree and afforded numerous places for fallen leaves to lodge. Hedges in the other areas of infestation prevented all fallen leaves from being raked clean and destroyed.

Methods and Materials

Leaves infested with larvae were gathered and placed in containers in an insectary for adult and parasite emergence.

For egg deposition, recently emerged adults were kept in small wire cages 1 foot wide, 1 foot high and 2 feet long. One female adult was placed in one cage; 6 adults, 3 females and 3 males were placed in a second cage; 12 adults, 6 females and 6 males were placed in a third cage and 24 adults, 12 females and 12 males were placed in a fourth cage. All tests were replicated 3 times. All cages contained 8 4-dram vials with 2 leaves inserted in each vial for egg deposition. A vial of water plugged with cotton was placed in each cage for adult moths.

Two methods for keeping the leaves turgid were tried. A half-inch galvanized pipe with 3 six-inch uprights 12 inches apart connected by one-half inch rubber tubing to a gallon jug of water was tried first. Half-inch rubber stoppers with a one-eighth inch hole in each stopper were fitted into the ends of the uprights with the plant part inserted into the hole in each stopper. Modeling clay was packed around the stem at the bottom end of each stopper to prevent any water leakage. A second method was tried and later used for all tests by placing 2 leaves with short stems in a 4-dram vial. A notch was cut in the side of the cork to accommodate the stem, and the cork was inserted into a vial filled with water. A plastic, opaque bag was placed over the plant parts, gathered around the vial and secured with a rubber band. As the adults emerged in these plastic bags, they were transferred to screened cages.

Two cages, 1 containing 12 and a second containing 24 adults, were placed in a temperature controlled room (74-80° F.). All tests were replicated 3 times. To obtain the average width of the head capsule, measurements were taken from 100 larvae in each instar. For peak emergence in the field, adults were counted on 10 leaves selected at random on 4 sides of a tree. Three sites were selected for these counts. Temperatures for field conditions were taken from the United States Weather Bureau Climatological Data Station, located at Gainesville.

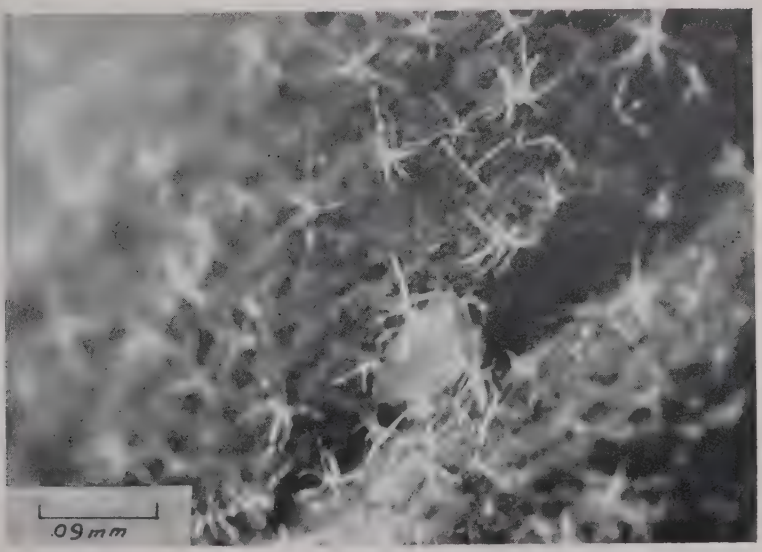

Figure 1. Egg of *Anchylopera platanana* Clemens.

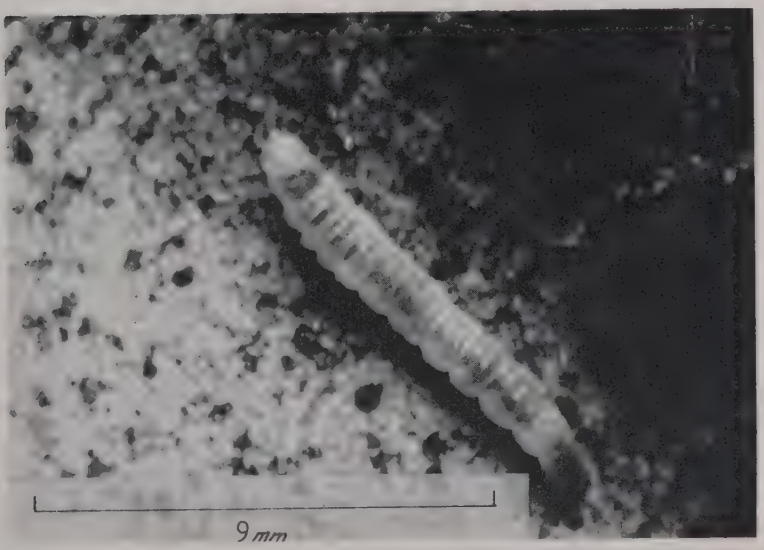

Figure 2. Larva of *Anchylopera platanana.*

Life Cycle

Eggs (Figure 1) resembling small, gelatinous droplets, round to oval in shape, almost colorless and approximately 0.09 mm. in size were laid on the leaves.

The last instar, pale yellow larvae (Figure 2) average 9-11 mm. in length. The average widths of head capsules of 100 larvae in the first, second, third and fourth instars are 0.20 mm., 0.33 mm., 0.60 mm. and 0.83 mm., respectively.

The larvae begin feeding at the base of the leaf on either side of the midrib. If more than 2 larvae are on one leaf, additional larvae begin their feeding farther up the leaf, usually where a vein branches.

The larvae spin fine, silken webs over the feeding area. The felty tomentum growing on the leaf, excrement and any other materials found on the surface of the leaf are removed and pushed under the edge or through the webbing before the larvae commence feeding. The larva attaches itself in an upside down position to the webbing, lowers its head to the surface of the leaf and begins to feed. The web is extended as more area is needed. The larva skeletonizes the leaf and forms a tuck along the skeletonized area by attaching a web to a vein on one side and to the leaf surface beyond the feeding area on the opposite side and draws the leaf together.

The pupa (Figure 3) is light yellow and averages about five millimeters in length. The larvae usually pupate within the folded area of the leaf, however, a larva may leave the folded area, spin a web on the adjacent surface of the leaf, and pupate beneath the web.

The adults have a wing spread of approximately 13 mm. The forewings are pale reddish with white markings along the costa and the base while the extreme apex is dark reddish. The hind wing, head, thorax and abdomen are whitish.

Under laboratory conditions, with a temperature range of 74-80° F. and relative humidity approximately 74 per cent, the average time required

TABLE 1.—Life Cycle of *Anchylopera platanana* Clemens in a Temperature Controlled Room—Range 74-80°F.

Stage of Development	Time in Number of Days		
	Minimum	Maximum	Average
Egg	3	5	4
First instar larva	2	3	2.5
Second instar larva	4	6	5
Third instar larva	6	8	7
Fourth instar larva	7	9	8
Pupa to adult	9	11	10
Gestation	5	6	5.5
Totals	36	48	42

Figure 3. Pupa of *Anchylopera platanana.*

Figure 4. Adults of *Anchylopera platanana.*

to complete the life cycle was 42 days (Table 1). Under insectary conditions, the average time to complete a life cycle was 45½ days (Table 2).

TABLE 2.—Life Cycle of *Anchylopera platanana* Clemens in an Insectary.

Stage of Development	Time in Number of Days		
	Minimum	Maximum	Average
Egg	3	5	4
First instar larva	2	4	3
Second instar larva	5	6	5.5
Third instar larva	7	8	7.5
Fourth instar larva	8	9	8.5
Pupa to adult	10	11	10.5
Gestation	5	6	5.5
Totals	40	49	45.5

No attempt was made to record the daily temperatures in the insectary as the temperature usually varies with the field temperature; however, periodic comparisons were made and the temperature in the insectary was usually five degrees higher.

Parasites and Predators

About 20 per cent of all the pupae collected in the fall of 1958 were parasitized with a chalcid (*Brachymeria* sp.).[5] Larvae of a chrysopid (*Chrysopa rufilabris* Burmeister)[6] were found feeding on the larvae of *A. platanana* in the summer of 1958.

No parasites were found in the first two generations in the spring of 1959. Less than 5 per cent of the pupae were parasitized in the third and fourth generations. The parasites were the same new species of chalcid, *Brachymeria* sp., and an eupelmid (*Eupelmus* sp.), *C. rufilabris* was present in large numbers in April, May and June. Twenty-two per cent of all the infested leaves in the field contained dead *A. platanana* larvae in the folded leaves. It is assumed that most of these larvae were killed by the chrysopids, as no other predators were observed and the larvae did not appear to be diseased. Undetermined species of spiders were found occasionally feeding on the adults of *A. platanana*.

Discussion

Single adult females in all cage tests failed to lay eggs and died after 6 to 7 days. In all other cages, eggs were deposited on the top surfaces along the midrib or lateral veins of the leaves in the late afternoon or

[5] Identified as a new species by B. D. Burks, U. S. National Museum, Washington, D. C.

[6] Identified by W. E. Bickley, Department of Entomology, University of Maryland, College Park, Maryland.

early evening. Very few eggs were deposited on the undersides of the leaves under laboratory conditions. In the field, eggs were usually laid on the under surfaces of the leaves along the midrib or lateral veins. Under caged conditions there were as many as 23 eggs laid on one leaf. Most of these were laid on the upper surfaces.

The slightly higher temperatures in the insectary apparently made little difference, as adults began emerging about the same time in both places. Peak emergence of adults in the field occurred about May 12, June 23, August 5 and September 18, 1959. These dates were selected as close as possible to the middle of the 7- or 8-day period when the largest number of adults were present in the field. There was some overlapping of the different stages in the third and fourth generations. This was due in part to the range of 5 to 6 days for egg laying.

The overwintering prepupal stage could be found in the folded areas of fallen leaves in the fall of 1958 and 1959. Adults were never observed to take food or water in the field or insectary, although water was supplied in each cage.

Summary

Heavy infestations were more generally found scattered throughout the Gainesville area in the summer of 1958, while only a few local heavy infestations, with widespread light infestations, were found in the spring and summer of 1959. One possible explanation for the larger population in 1958 was that the parasites and predators probably did not survive the below-normal temperatures in the fall of 1957 and the spring of 1958 as well as did *A. platanana*. Only an occasional chrysopid larva was found feeding on *A. platanana* in the summer of 1958, and approximately 20 per cent of the pupae were parasitized in the fall of 1958. Chrysopid larvae were numerous following a mild fall and winter in 1958-59 and helped reduce the population of the first, second and third generations. No parasites were found in the first and second generations, and less than 5 per cent of the third and fourth generations were parasitized in 1959. The over-all population of *A. platanana* had been reduced by predators in the spring, and with the presence of a few parasites in the late summer and fall it was difficult to find larvae and only an occasional prepupa stage after October 1, 1959. Parasites and predators apparently can keep this pest under control in Florida provided weather conditions are favorable.

Literature Cited

Clemens, Brackenridge. 1860. Contributions to American lepidopterology No. 6. Proc. Acad. Nat. Sci. Phila. 2d ser. [v. 12]:349.

Fernald, C. H. 1903. (In Dyar, Harrison G., A list of North American Lepidoptera and key to the literature of this order of insects.) U. S. Nat. Mus. Bul. 52:468.

Mackay, Margaret Rae. 1959. Larvae of the North American Olethreutidae (Lepidoptera). Canad. Ent. Supplement 10. 91:153.

Walsingham, Lord Thomas de Grey. 1884. North American Tortricidae. Trans. Ent. Soc. Lond. Pt. 1 (April):145.

Zeller, P. C. 1875. Beitrage zur Kenntniss der nordamericanishen Nachtsalter, bersonders der Microlepidopteren. Verh. Zool.- bot. Ges. Wien 25:207-360.

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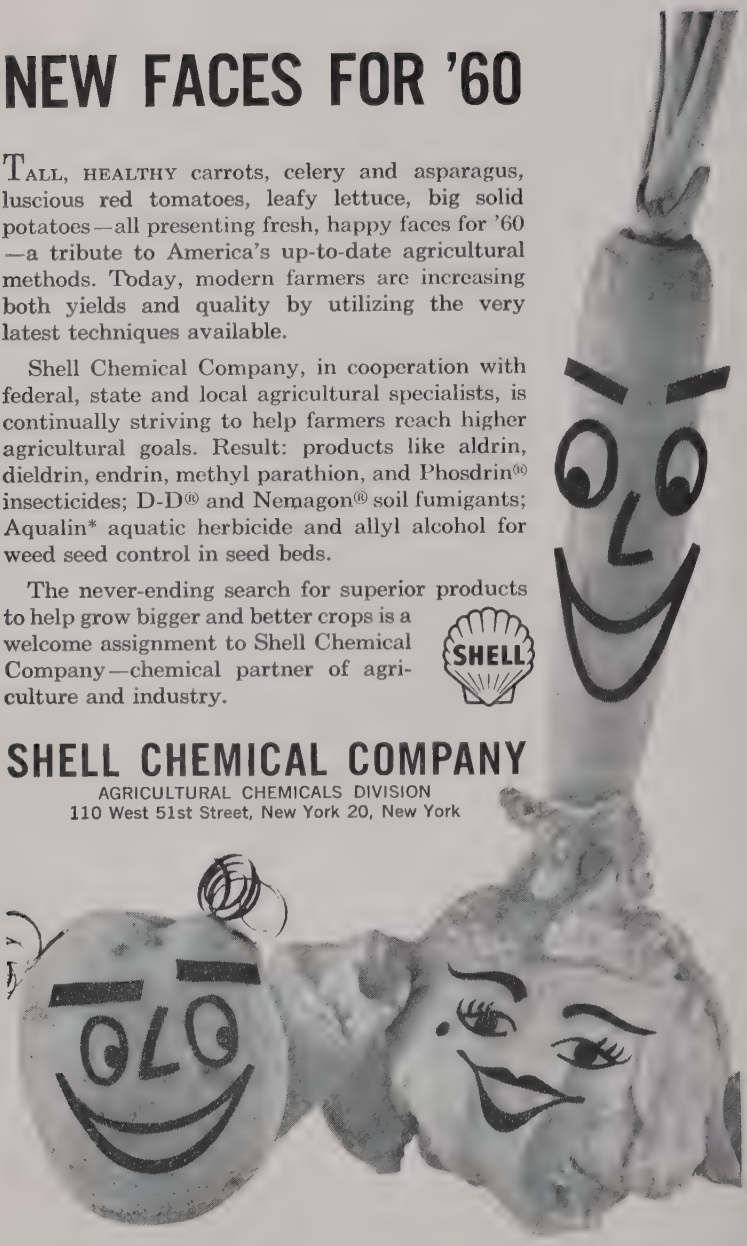

SOME NATURAL ENEMIES OF THE WHITE PEACH SCALE, *PSEUDAULACASPIS PENTAGONA* (TARGIONI) (HOMOPTERA: COCCOIDEA) IN FLORIDA [1]

IDWAL WYN HUGHES [2] [3]

The white peach scale, *Pseudaulacaspis pentagona* (Targioni), was first observed in Florida in 1889 on peach trees in the vicinity of Molino (Gossard, 1902). Since that time *P. pentagona* has spread throughout the state and is now known to attack more than 60 species of plants (Riddick, 1955).

The natural enemies of the white peach scale have been adequately recorded in many areas of the world (Anonymous, 1944; Bennett, 1956; Simmonds, 1958). However, except for an early report by Gossard (1902) telling of the twice-stabbed lady beetle, *Chilocorus stigma* (Say), feeding on white peach scale, published records of natural enemies of this scale in Florida are lacking. The records of parasites and predators which follow were gathered during the period May 1, 1959, to October 1, 1959, primarily from Alachua County.

METHODS

Careful examinations of white peach scale infestations were made in 8 separate field locations in Alachua County and all parasites and predators observed were collected. Small sections of scale-infested twigs and branches were returned to the laboratory from the collection sites and placed in emergence boxes. Twenty-three samples, each consisting of at least 300 scales were gathered with a minimum of 2 samples coming from each of the collection areas. In addition, to establish authentic parasite-host relationships, parasitized scales from each collection area were placed individually in 1-dram vials where they were kept until the adult parasites emerged. Dissections of scales were also carried out under a microscope.

Through the cooperation of Mr. Harold Denmark, Chief Entomologist with the State Plant Board of Florida, arrangements were made to have plant material infested with *P. pentagona* sent to the author in Gainesville by State Plant Board field inspectors working in various parts of Florida. In this manner small quantities of white peach scale were obtained from Baker, Jefferson, Lake, Orange, and Volusia Counties. Recoveries made from this material have been recorded here; however, many additional samples of *P. pentagona* would be required before an accurate estimate

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[1] A portion of a thesis submitted as partial fulfillment for the degree of Master of Science in Agriculture at the University of Florida, January, 1960.

[2] Assistant Director of Agriculture, Bermuda.

[3] The author is indebted to the following persons for advice and assistance: Dr. John T. Creighton, Dr. L. A. Hetrick, Dr. T. J. Walker, Dr. Milledge Murphey, Jr., and Professor A. S. Muller, all of whom are on the faculty of the University of Florida. Acknowledgment is also made to Dr. Paul W. Oman, Head of the Insect Identification and Parasite Research Branch, U.S.D.A., and his staff, for determining parasites and predators collected.

could be made of the distribution and abundance of natural enemies of this scale within these 5 counties.

Results and Discussion

Two species of primary hymenopterous parasites were reared from field-collected samples of white peach scale. In addition, 2 hyperparasitic species were recovered.

The most common and most effective parasite of the white peach scale in Florida appears to be the eulophid *Prospaltella berlesei* (Howard). This species is endoparasitic in nature and attacks second-instar scales, principally females. The parasite was recovered from every area in the state in which samples of *P. pentagona* were secured.

There was no attempt to make detailed counts to determine the percentage of scales attacked by *P. berlesei* on the various samples. Spot counts indicated, however, that there can be a great variation in the degree of parasitism, even within small areas. Despite local variations in effectiveness, *P. berlesei* must be considered an important agent in the control of the white peach scale in Florida.

The second of the primary parasites recovered from *P. pentagona* was *Aspidiotiphagus citrinus* (Crawford). This species was far less common than *Prospaltella berlesei*, being recorded from only 2 of the 8 collection areas in Alachua County, and from a single area in Baker County. *A. citrinus* attacks second-instar male and female scales and is an endoparasite.

It is surprising that *A. citrinus* was not recovered more commonly since this species has been recorded attacking purple scale, *Lepidosaphes beckii* (Newman), and Florida red scale, *Chrysomphalus aonidum* (Linnaeus) (Muma, 1955), and is presumed to be distributed throughout the State of Florida. Seasonal variations in population of this parasite might account for the poor recovery record since all investigations were conducted during the summer months.

The effectiveness of *Prospaltella berlesei* was reduced considerably by the hyperparasite *Thysanus flavopalliatus* (Ashmead), which was commonly found attacking pupae of the primary parasite within the mummified bodies of *P. pentagona* (Fig. 1). *T. flavopalliatus* was recovered from every collection area with the exception of Lake County. Small numbers of the eulophid *Ablerus clisiocampae* (Ashmead), recorded as a hyperparasite on *Prospaltella aurantii* (Howard) by Muma (1959), were also recovered from white peach scale. The identity of the primary parasite through which *Ablerus clisiocampae* was developing was not definitely established, but in all probability it was *Prospaltella berlesei.*

Three species of coccinellids were found feeding on white peach scale. Two of these species, the twice-stabbed lady beetle, *Chilocorus stigma* (Say), and *Lindorus lophanthae* (Blaisdell) were common and very effective predators. The third species, *Exochomus childreni* Mulsant, was found only occasionally and never in large numbers.

Further investigation would undoubtedly uncover additional coccinellids predacious on *P. pentgona* in Florida since several of the species listed by Merrill (1922) as occurring in Florida are known to attack white peach scale in other geographical areas (Bennett and Hughes, 1959).

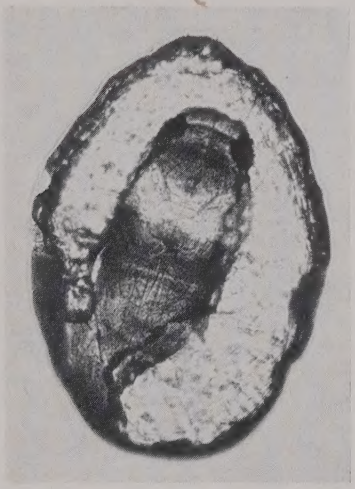

Fig. 1.—Dorsal view of fully developed pupa of *Thysanus flavopalliatus* within a second-instar female of the white peach scale, *Pseudaulacaspis pentagona*. *Thysanus flavopalliatus* is secondary through *Prospaltella berlesei*.

In addition to the coccinellids, a species of thrips, a lepidopterous larva, and a chrysopid larva were recorded in association with white peach scale. The thrips, *Haplothrips* sp. nr. *americanus* (Hood), was quite common, particularly when scale infestations were heavy. This thrips species is apparently a scavenger rather than a predator.

Larvae of the cosmopterygid moth, *Pyroderces rileyi* (Walsingham), were recovered regularly from white peach scale material. The larvae tunnel among encrusted scales, living as scavengers.

Several larvae of an unidentified chrysopid were collected in association with *P. pentagona* infestations in the Gainesville area. While the larvae were apparently feeding on one or more stages of the scale, the number of these predators was so small as to make them economically unimportant.

Summary

An investigation of the natural enemies of white peach scale, *Pseudaulacaspis pentagona* (Targioni), was conducted in Alachua County, Florida, during the summer of 1959. Two parasites, *Prospaltella berlesei* (Howard) and *Aspidiotiphagus citrinus* (Crawford), along with the coccinellid predators *Chilocorus stigma* (Say), *Lindorus lophanthae* (Blaisdell), and *Exochomus childreni* Mulsant, were recorded as attacking *P. pentagona*. *Thysanus flavopalliatus* (Ashmead), a secondary parasite through *P. berlesei*, was very common.

LITERATURE CITED

Anonymous. 1944. A catalogue of the parasites and predators of insect pests. Section 1, part 3. The Imperial Parasite Service, Belleville, Ontario.

Bennett, F. D. 1956. Some parasites and predators of *Pseudaulacaspis pentagona* (Targ.) in Trinidad, B.W.I. Can. Ent. 88:704-705.

Bennett, F. D., and *I. W. Hughes.* 1959. Biological control of insect pests in Bermuda. Bull. Ent. Res. 50:423-436.

Gossard, H. A. 1902. Two peach scales. Fla. Agr. Exp. Sta. Bull. 61: 492-498.

Merrill, G. B. 1922. Lady beetles of Florida. State Plant Board of Fla. Quart. Bull. 6(2):1-46.

Muma, M. H. 1955. Factors contributing to the natural control of citrus insects and mites in Florida. Jour. Econ. Ent. 48:332-338.

Muma, M. H. 1959. Natural control of Florida red scale on citrus in Florida by predators and parasites. Jour. Econ. Ent. 52:577-586.

Riddick, Eloise. 1955. Check list of hosts of scale-insects of Florida. State Plant Board of Fla. Bull. 7:1-78.

Simmonds, F. J. 1958. The oleander scale, *Pseudaulacaspis pentagona* (Targ.), (Homoptera, Coccidae) in Bermuda. Bermuda Dept. Agr. Bull. 31:1-43.

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A LYGAEID NEW TO THE UNITED STATES LIST (HEMIPTERA).—*Pachybrachius neotropicalis* (Kirkaldy 1909), earlier known by the preoccupied name *serripes* (Fabr. 1803), is widely distributed in the Neotropical Region, including the West Indies, but has not been reported heretofore from the United States. I have recently seen a male and a female from Miami, Florida, in the collection of the State Plant Board of Florida. These were taken in traps, situated about 5 miles apart, on November 23 and November 25, 1959, respectively.

P. neotropicalis is nearly twice as large (9½ to 10 mm.) as the largest *Pachybrachius* reported previously from the United States, and is further distinguished easily by the much more slender front femora and the blackish pronotum with four very small, rusty spots on the posterior lobe. As in *P. albocinctus* Barber, the basal portion of the fourth antennal segment is very broadly white.—ROLAND F. HUSSEY, *Biology Department, University of Florida, Gainesville.*

JOSEPH WILLIAM DECKER

Word has recently been received of the death of J. William Decker, 76 years of age. Mr. Decker was associated with the Fort Clinch State Park for 19 years and was responsible for the development of the excellent museum associated with the old fort. Last year he retired from the State Park Service and was engaged in the development of a private museum at Fernandina Beach at the time of his death. He is survived by his wife, Mrs. Sadie Decker, and son, Douglas William Decker, who plan to complete and operate the private museum. Mr. Decker trained as an engraver and silversmith in Germany as a young man. In addition to his many historical interests, he was a naturalist in the very broadest sense. His interest in insects is evident from his many years of membership in Florida Entomological Society.

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